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(12) **United States Patent**
Silberstein

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(45) **Date of Patent: May 1, 2012**

(54) **PHOTOGRAPHY-SPECIFIC DIGITAL CAMERA APPARATUS AND METHODS USEFUL IN CONJUNCTION THEREWITH**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 777 days.

(21) Appl. No.: **11/175,791**

(22) Filed: **Jul. 5, 2005**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
H04N 5/225 (2006.01)
H04N 7/18 (2006.01)
G06K 9/00 (2006.01)

(52) **U.S. Cl.** **348/207.99**; 348/169; 348/157; 382/118

(58) **Field of Classification Search** 348/207.99, 348/222.1, 169, 157, 333.02; 382/118
See application file for complete search history.

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Primary Examiner — Nhan T Tran
(74) *Attorney, Agent, or Firm* — Fish & Richardson P.C.

(57) **ABSTRACT**

A multi-mode digital photography method including generating an output image of a location L at a specific time t which is identified as a function of a user-selected photography task. the method including generating an output image of a particular scene which is built up from a plurality of images thereof, as another function of a user-selected photography task.

18 Claims, 56 Drawing Sheets

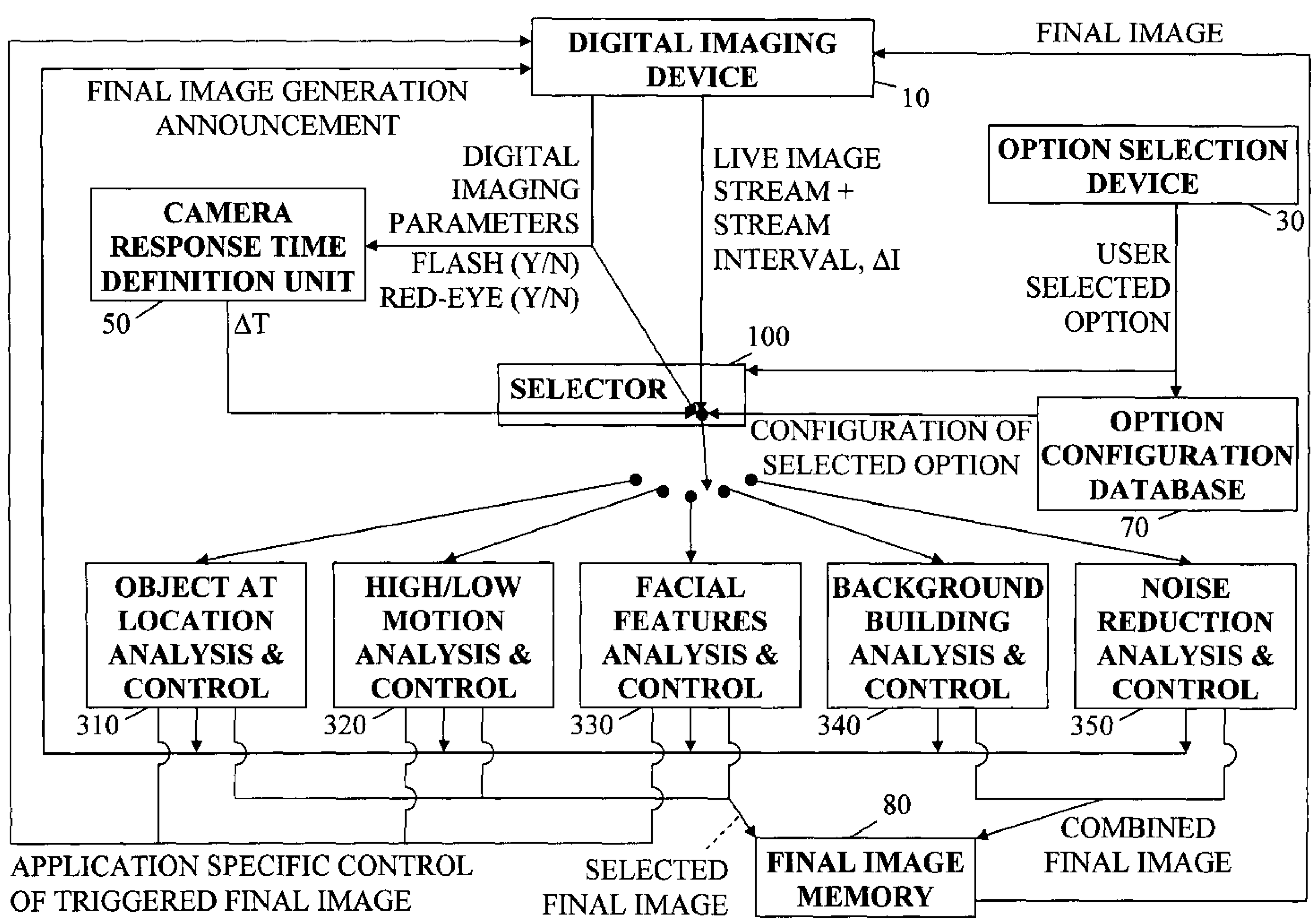


FIG. 1

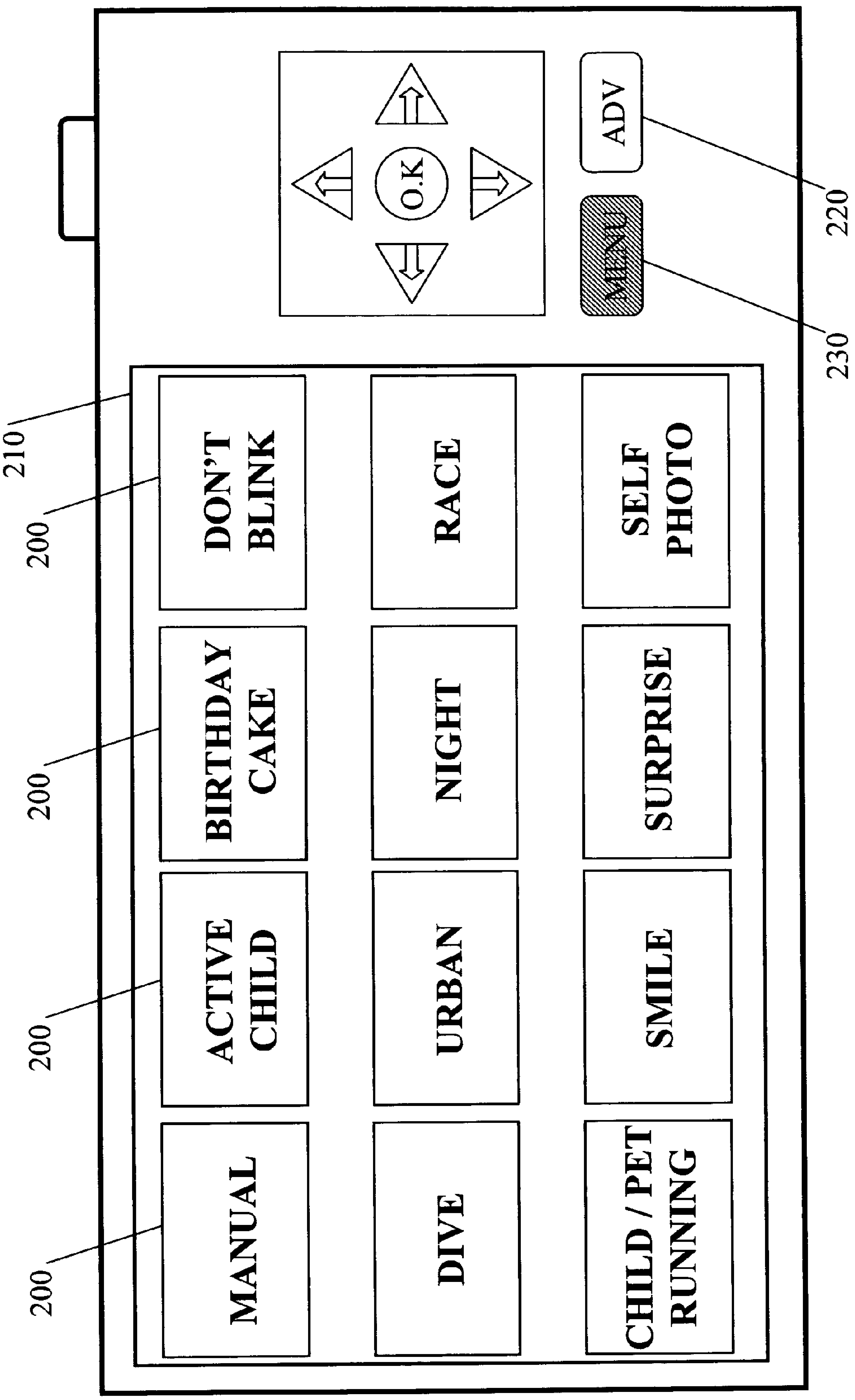
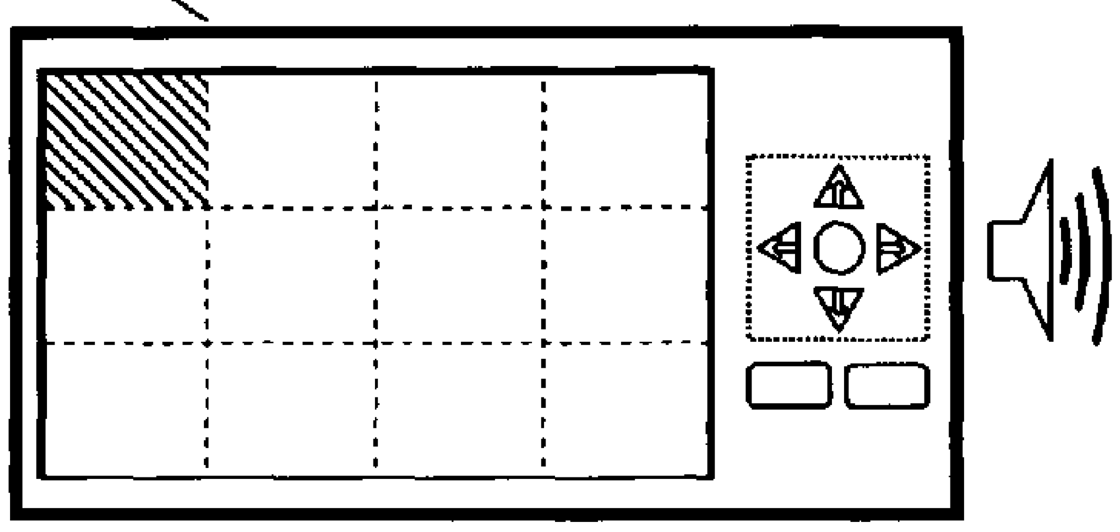

MANUAL
ACTIVE CHILD
BIRTHDAY CAKE
DON'T BLINK
DIVE
URBAN
NIGHT
RACE
CHILD / PET RUNNING
SMILE
SURPRISE
SELF PHOTO
O.K
MENU
ADV
200
200
200
200
210
220
230

FIG. 2A

240

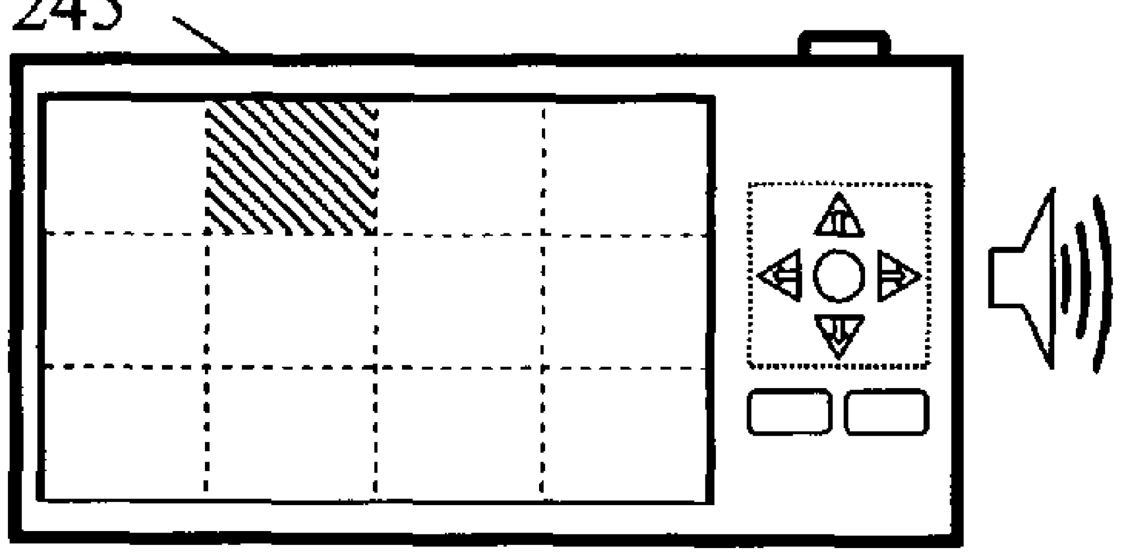


SELECTION OF
"MANUAL" OPTION

MANUAL

FIG. 2B

245



SELECTION OF "ACTIVE
CHILD" OPTION

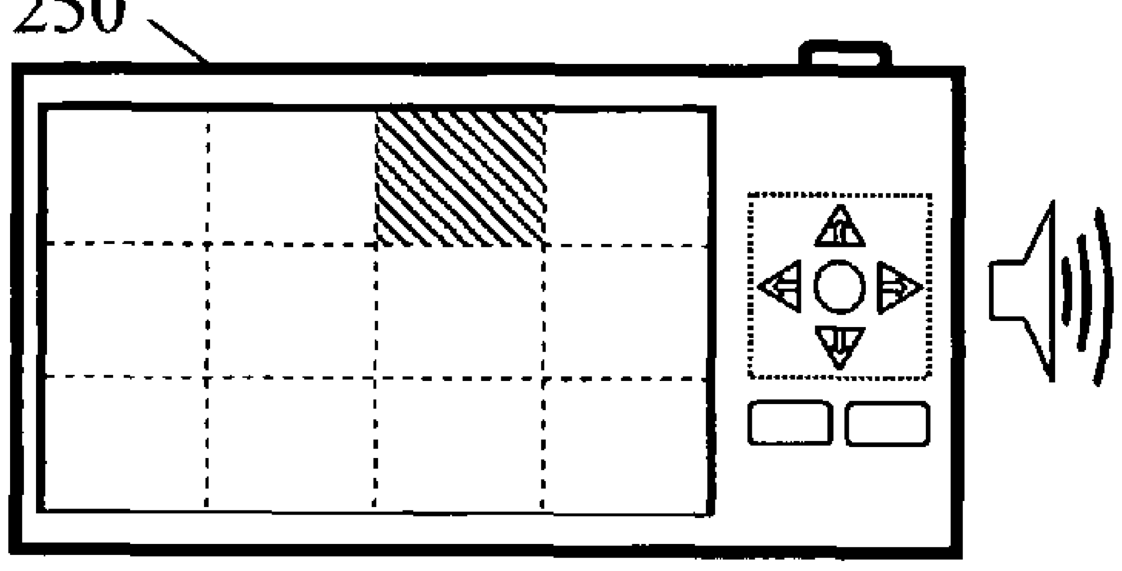
POSITION YOUR CHILD AT A DESIRED LOCATION.

POINT THE CAMERA AT THE CHILD.

PRESS THE SHUTTER BUTTON AND KEEP THE CAMERA STILL UNTIL YOU HEAR A BEEP.

FIG. 2C

250



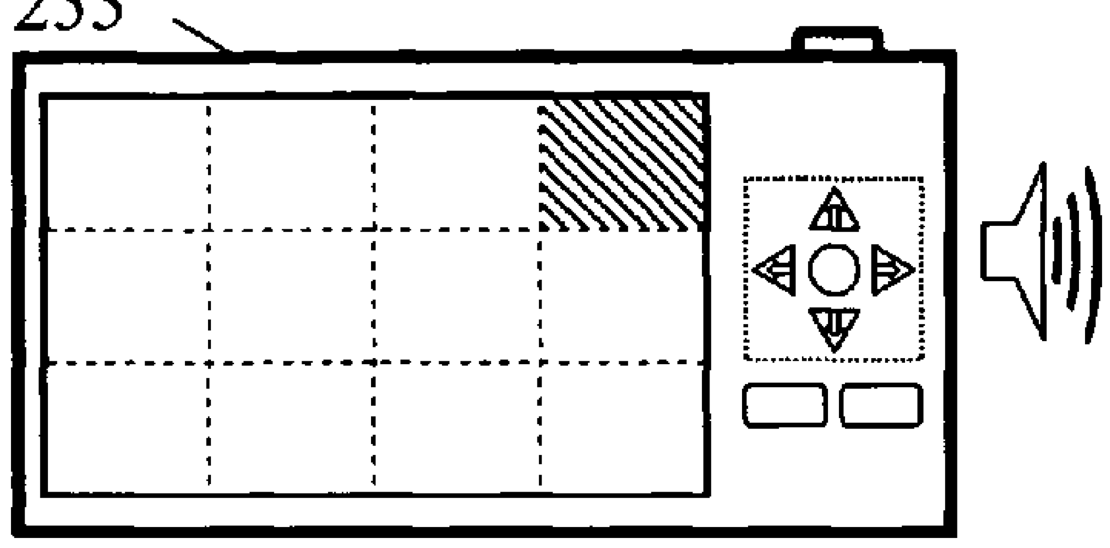
SELECTION OF
"BIRTHDAY CAKE"
OPTION

POINT THE CAMERA AT THE FLAMES OF THE CANDLES.

PRESS THE SHUTTER BUTTON AND KEEP THE CAMERA STILL UNTIL YOU HEAR A BEEP.

FIG. 2D

255



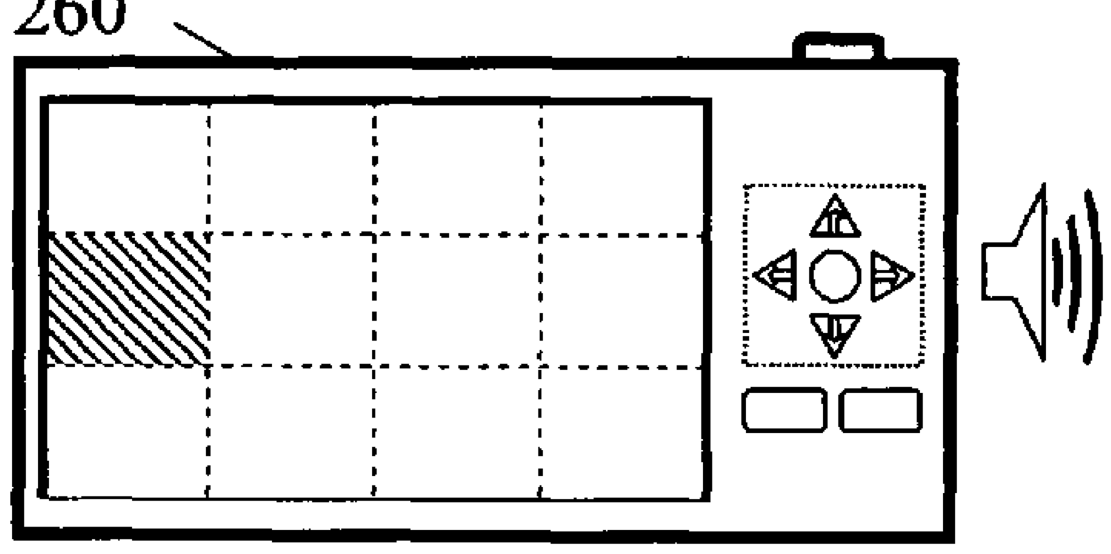
SELECTION OF “DON’T BLINK” OPTION

POINT THE CAMERA AT YOUR SUBJECT'S FACE.

PRESS THE SHUTTER BUTTON AND KEEP THE CAMERA STILL UNTIL YOU HEAR A BEEP.

FIG. 2E

260



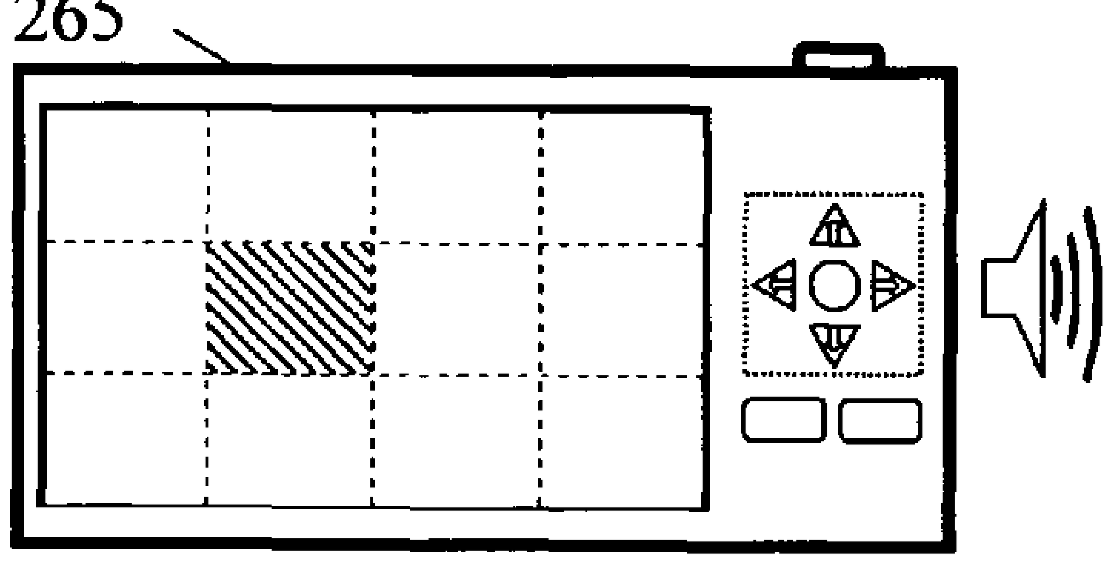
SELECTION OF “DIVE” OPTION

POINT THE CAMERA AT THE AIRSPACE IN FRONT OF THE DIVING BOARD OR AT THE WATER BENEATH THE DIVING BOARD.

PRESS THE SHUTTER BUTTON AND KEEP THE CAMERA STILL UNTIL YOU HEAR A BEEP.

FIG. 2F

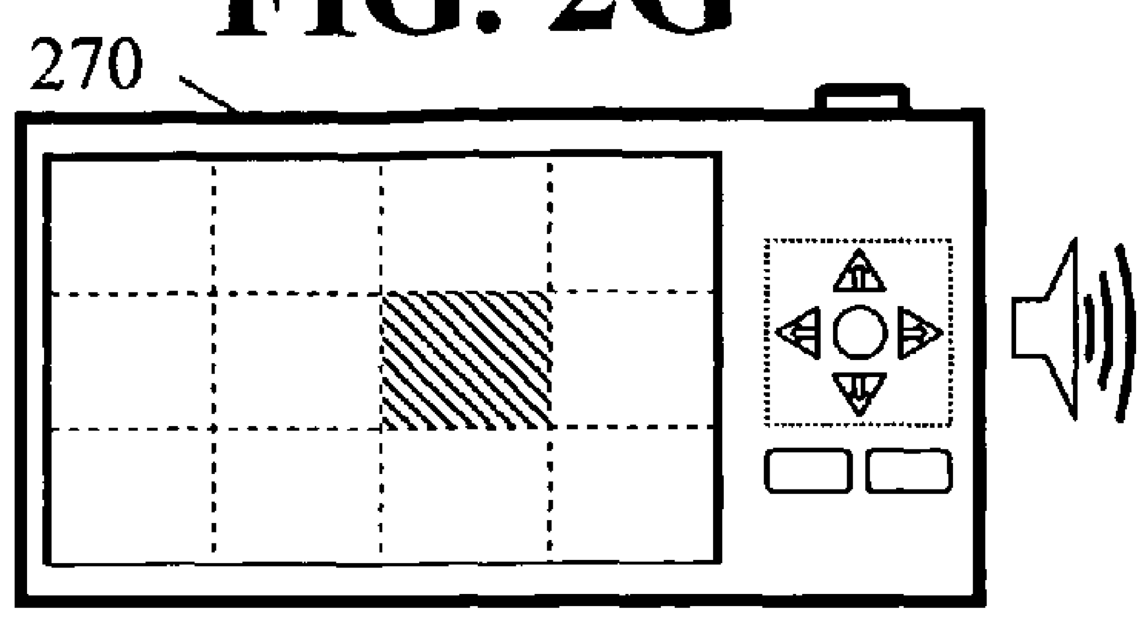
265



SELECTION OF “URBAN” OPTION

POINT THE CAMERA AT YOUR URBAN SCENE. DON'T WORRY ABOUT PEOPLE OR CARS OBSTRUCTING THE SCENE. YOUR CAMERA WILL ERASE THEM FOR YOU.PRESS THE SHUTTER BUTTON AND KEEP THE CAMERA STILL UNTIL YOU HEAR A BEEP. BE PATIENT - THIS MAY TAKE A WHILE.

FIG. 2G



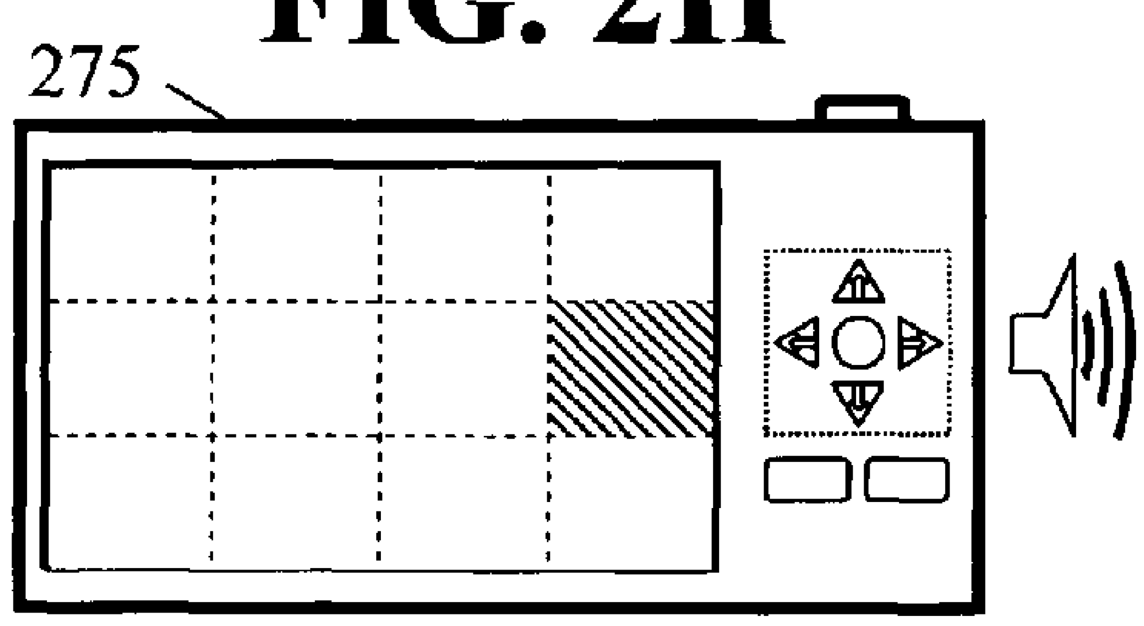
SELECTION OF "NIGHT" OPTION

POINT THE CAMERA AT YOUR NIGHT SCENE.

PRESS THE SHUTTER BUTTON AND KEEP THE CAMERA STILL UNTIL YOU HEAR A BEEP.

BE PATIENT - THIS MAY TAKE A WHILE.

FIG. 2H

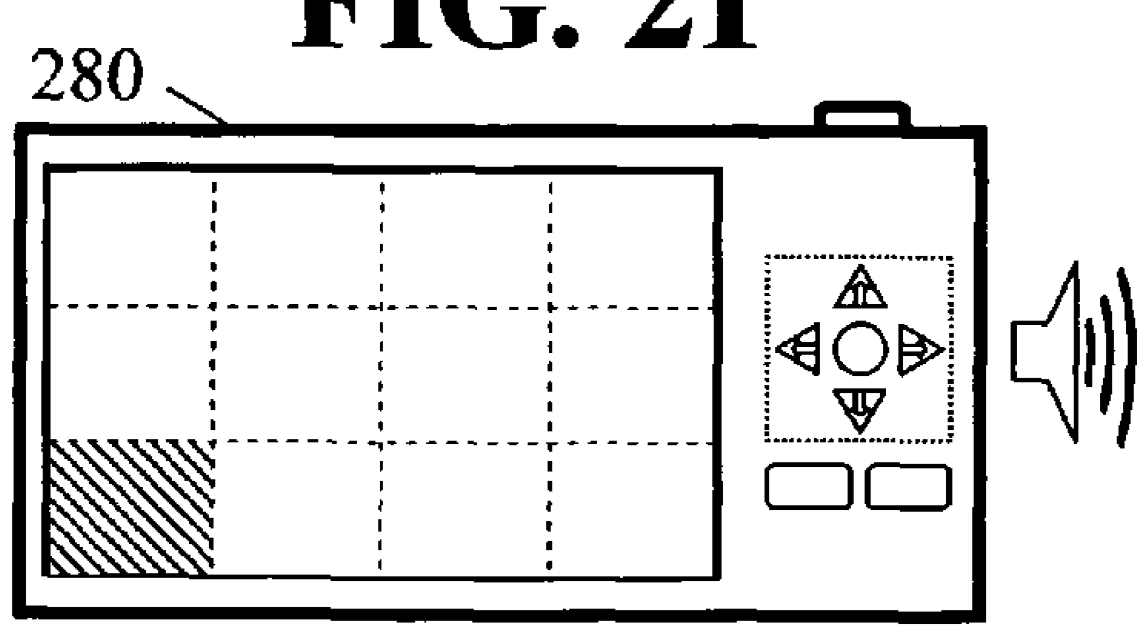


SELECTION OF "RACE" OPTION

POINT THE CAMERA AT THE FINISH LINE.

PRESS THE SHUTTER BUTTON AND KEEP THE CAMERA STILL UNTIL THE RACE IS OVER AND YOU HAVE HEARD A CONFIRMING BEEP.

FIG. 2I



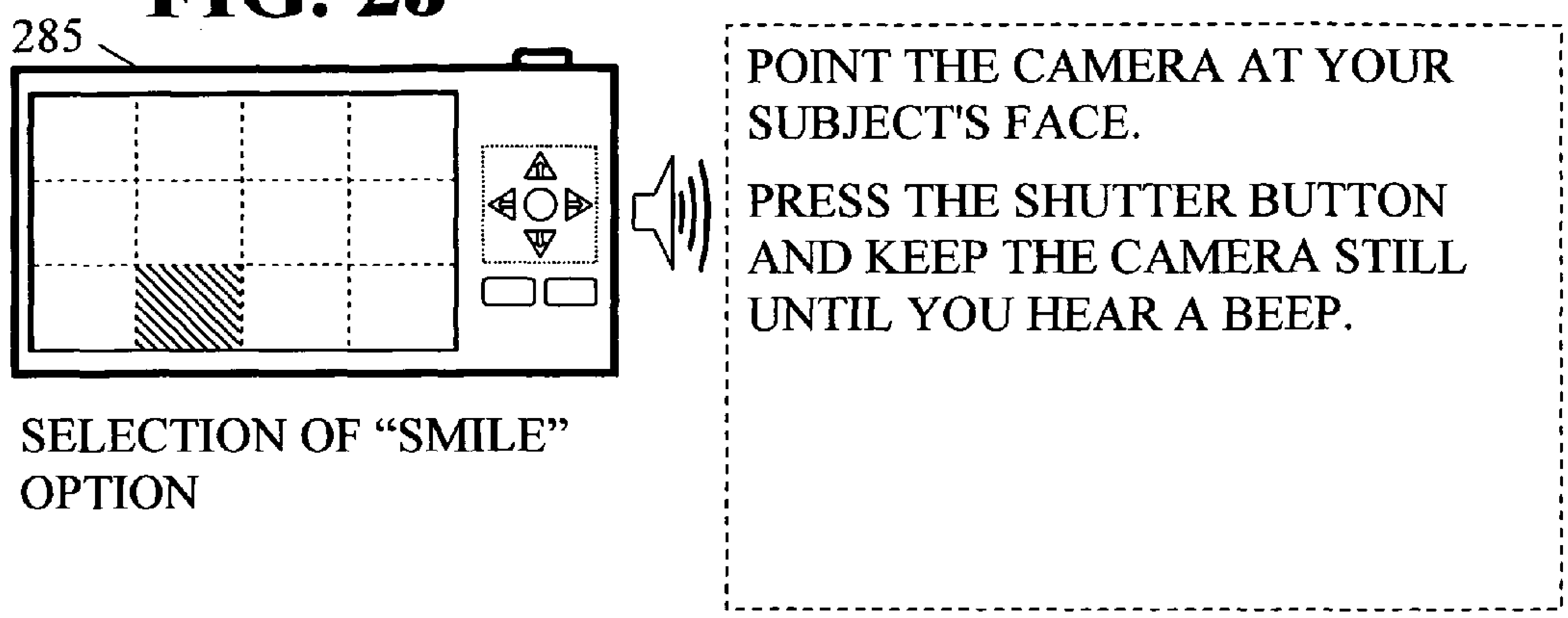
SELECTION OF "CHILD / PET RUNNING" OPTION

CHOOSE A LOCATION.

THE CAMERA WILL PHOTOGRAPH YOUR SUBJECT AS IT RUNS BY THIS LOCATION.

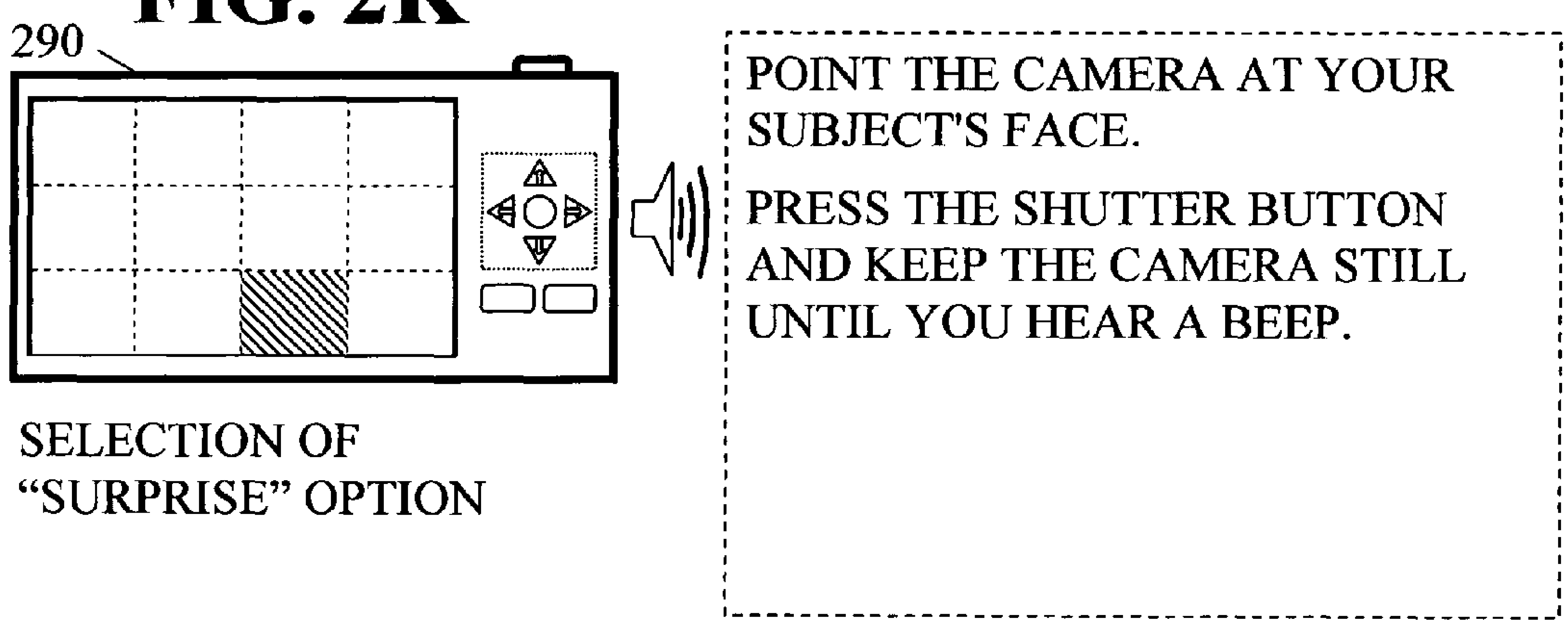
POINT THE CAMERA AT THIS LOCATION, PRESS THE SHUTTER BUTTON AND KEEP THE CAMERA STILL UNTIL YOU HEAR A BEEP.

FIG. 2J



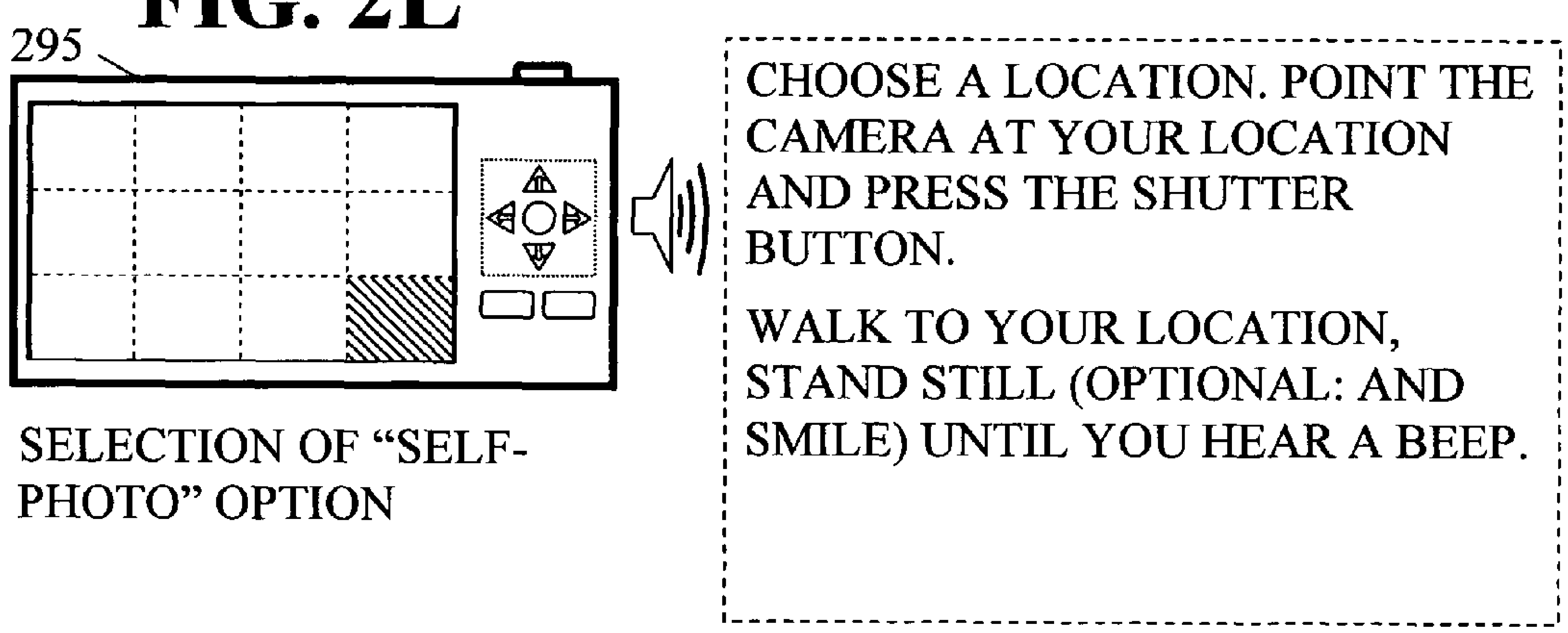
SELECTION OF "SMILE" OPTION

FIG. 2K



SELECTION OF "SURPRISE" OPTION

FIG. 2L



SELECTION OF "SELF-PHOTO" OPTION

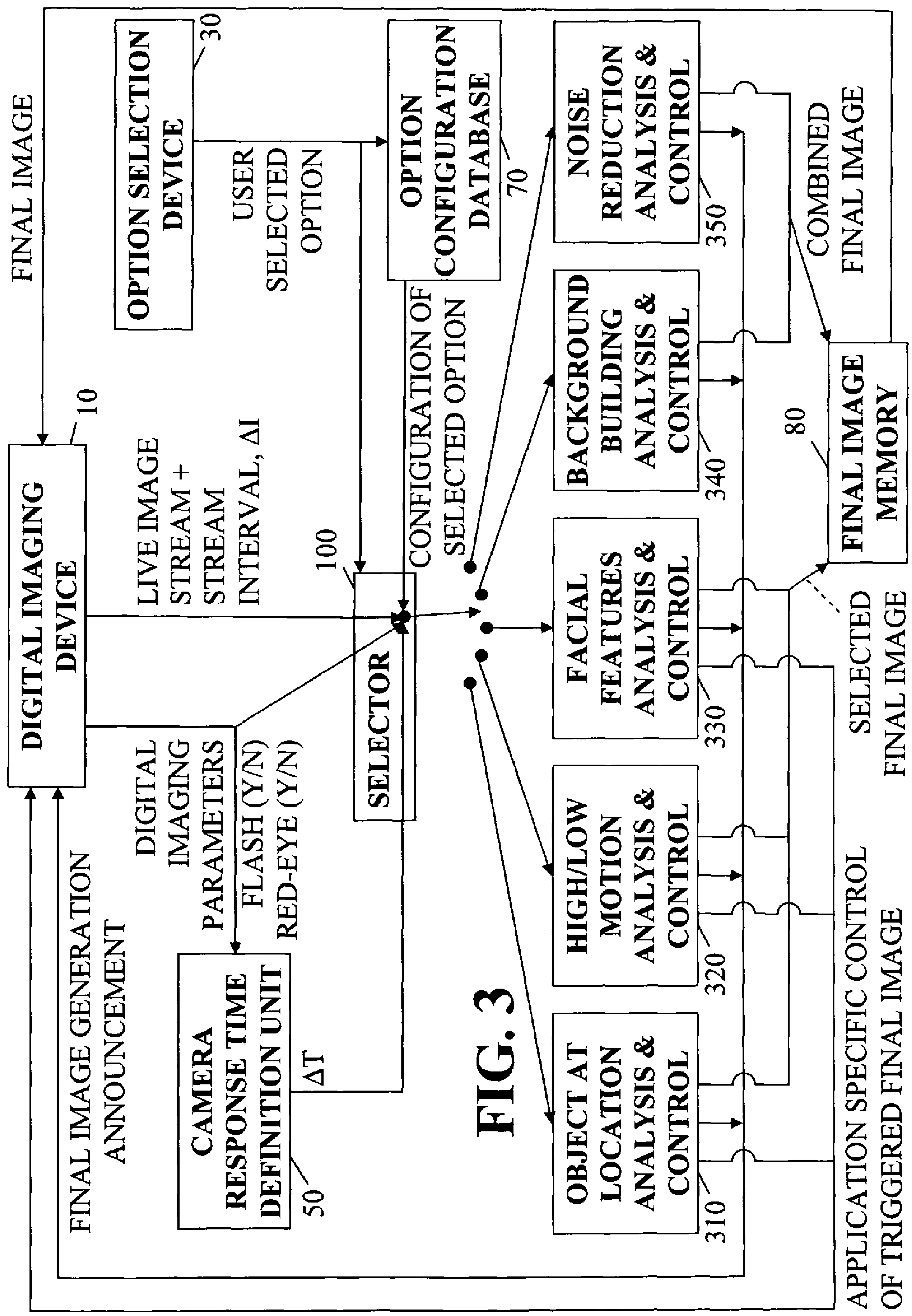
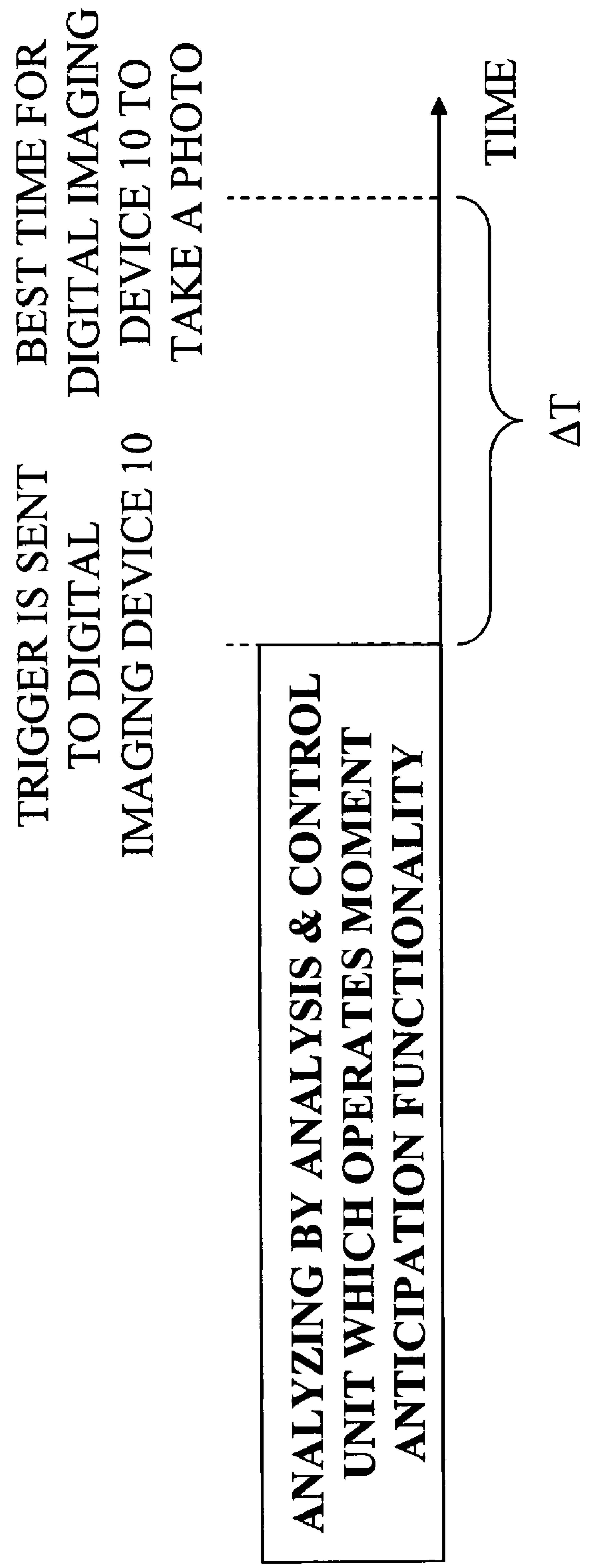

FINAL IMAGE
OPTION SELECTION DEVICE
30
USER SELECTED OPTION
OPTION CONFIGURATION DATABASE
70
DIGITAL IMAGING DEVICE
10
LIVE IMAGE STREAM + STREAM INTERVAL, ΔI
100
SELECTOR
CONFIGURATION OF SELECTED OPTION
DIGITAL IMAGING PARAMETERS
FLASH (Y/N)
RED-EYE (Y/N)
FINAL IMAGE GENERATION ANNOUNCEMENT
CAMERA RESPONSE TIME DEFINITION UNIT
50
ΔT
NOISE REDUCTION ANALYSIS & CONTROL
350
BACKGROUND BUILDING ANALYSIS & CONTROL
340
FACIAL FEATURES ANALYSIS & CONTROL
330
HIGH/LOW MOTION ANALYSIS & CONTROL
320
OBJECT AT LOCATION ANALYSIS & CONTROL
310
COMBINED FINAL IMAGE
FINAL IMAGE MEMORY
80
SELECTED FINAL IMAGE
APPLICATION SPECIFIC CONTROL OF TRIGGERED FINAL IMAGE

FIG. 3

FIG. 4



ANALYZING BY ANALYSIS & CONTROL UNIT WHICH OPERATES MOMENT ANTICIPATION FUNCTIONALITY
TRIGGER IS SENT TO DIGITAL IMAGING DEVICE 10
BEST TIME FOR DIGITAL IMAGING DEVICE 10 TO TAKE A PHOTO
ΔT
TIME

FIG. 5A

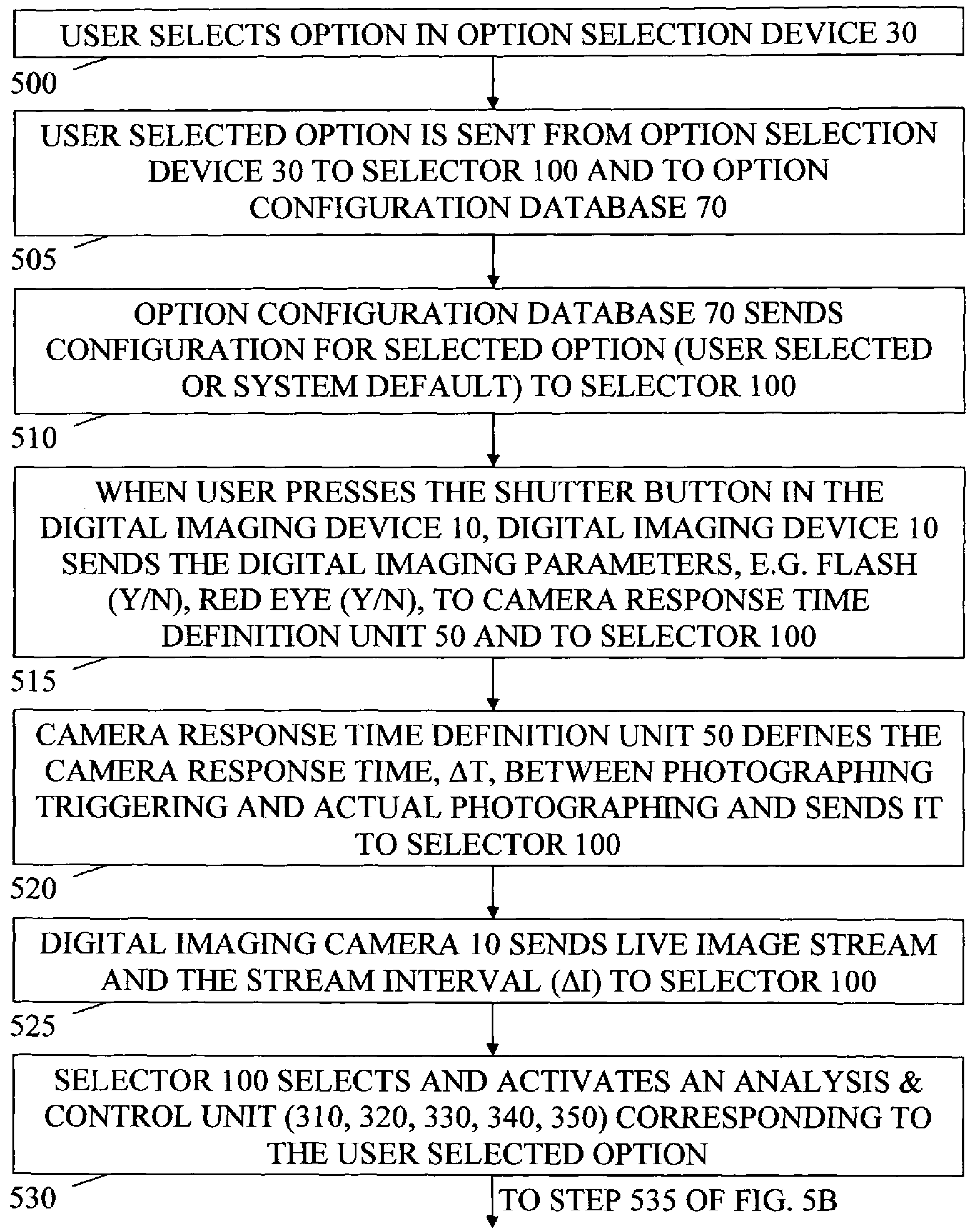
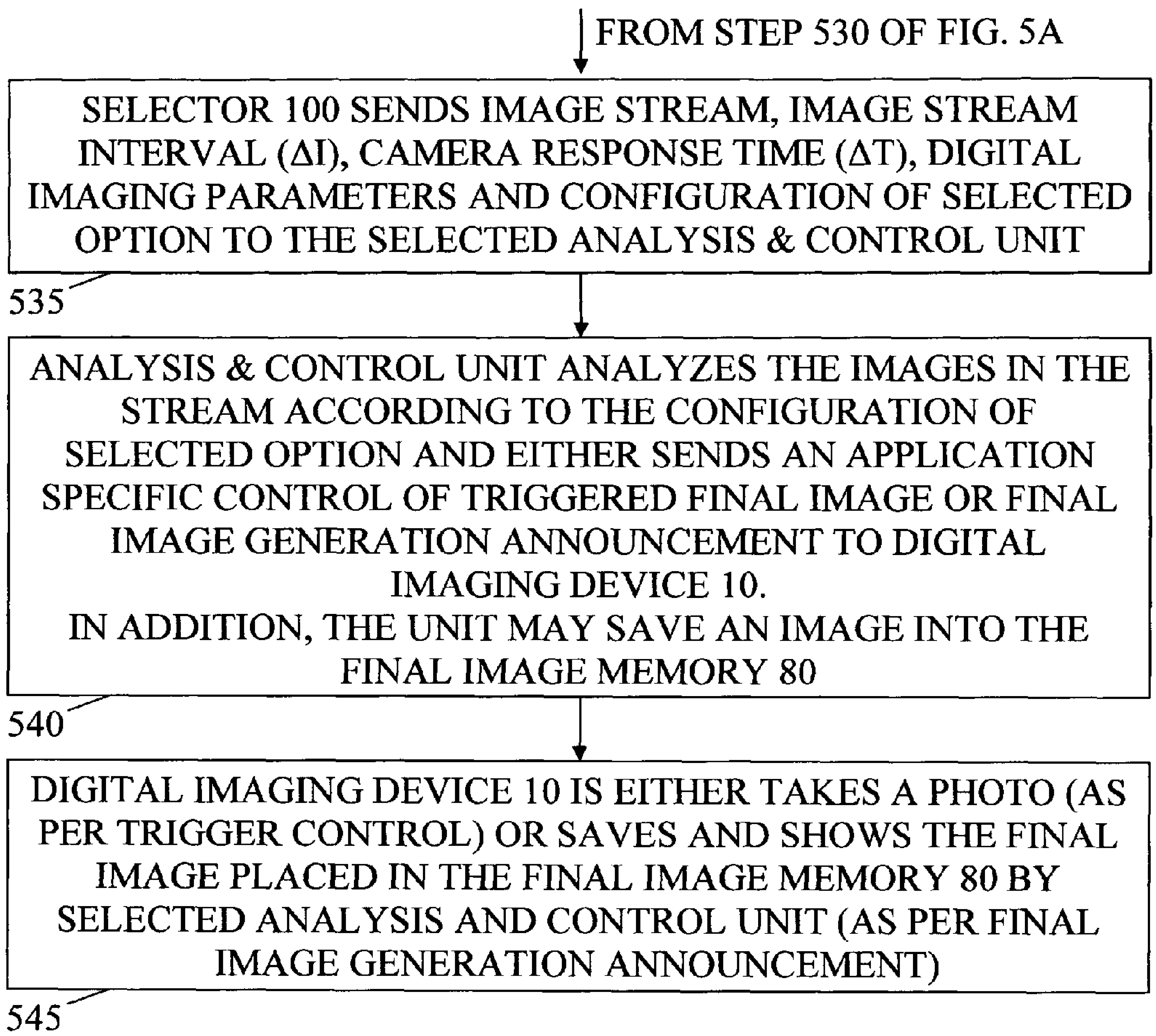
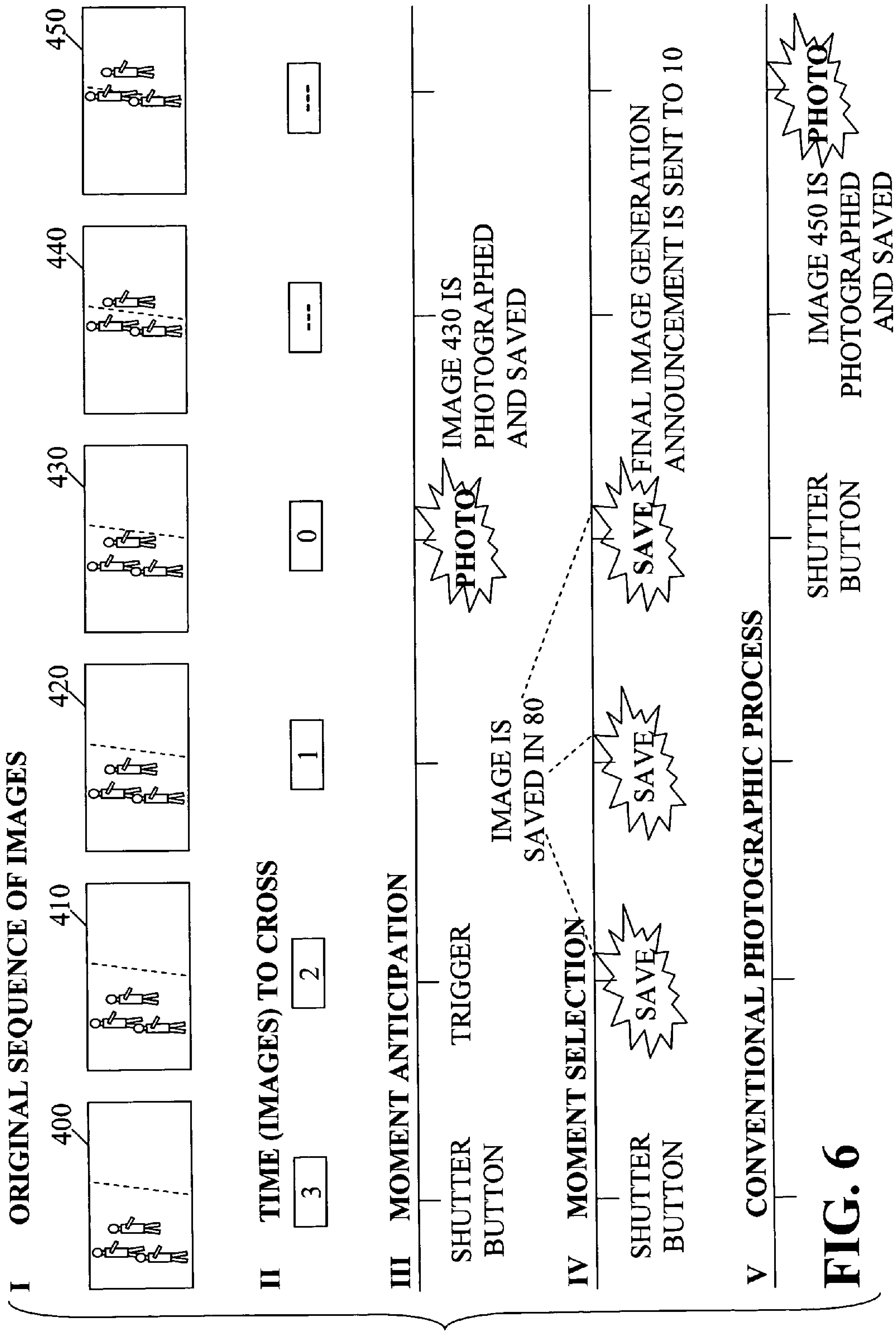

USER SELECTS OPTION IN OPTION SELECTION DEVICE 30
500
USER SELECTED OPTION IS SENT FROM OPTION SELECTION DEVICE 30 TO SELECTOR 100 AND TO OPTION CONFIGURATION DATABASE 70
505
OPTION CONFIGURATION DATABASE 70 SENDS CONFIGURATION FOR SELECTED OPTION (USER SELECTED OR SYSTEM DEFAULT) TO SELECTOR 100
510
WHEN USER PRESSES THE SHUTTER BUTTON IN THE DIGITAL IMAGING DEVICE 10, DIGITAL IMAGING DEVICE 10 SENDS THE DIGITAL IMAGING PARAMETERS, E.G. FLASH (Y/N), RED EYE (Y/N), TO CAMERA RESPONSE TIME DEFINITION UNIT 50 AND TO SELECTOR 100
515
CAMERA RESPONSE TIME DEFINITION UNIT 50 DEFINES THE CAMERA RESPONSE TIME, ΔT, BETWEEN PHOTOGRAPHING TRIGGERING AND ACTUAL PHOTOGRAPHING AND SENDS IT TO SELECTOR 100
520
DIGITAL IMAGING CAMERA 10 SENDS LIVE IMAGE STREAM AND THE STREAM INTERVAL (ΔI) TO SELECTOR 100
525
SELECTOR 100 SELECTS AND ACTIVATES AN ANALYSIS & CONTROL UNIT (310, 320, 330, 340, 350) CORRESPONDING TO THE USER SELECTED OPTION
530
TO STEP 535 OF FIG. 5B

FIG. 5B


FROM STEP 530 OF FIG. 5A
SELECTOR 100 SENDS IMAGE STREAM, IMAGE STREAM INTERVAL (ΔI), CAMERA RESPONSE TIME (ΔT), DIGITAL IMAGING PARAMETERS AND CONFIGURATION OF SELECTED OPTION TO THE SELECTED ANALYSIS & CONTROL UNIT
535
ANALYSIS & CONTROL UNIT ANALYZES THE IMAGES IN THE STREAM ACCORDING TO THE CONFIGURATION OF SELECTED OPTION AND EITHER SENDS AN APPLICATION SPECIFIC CONTROL OF TRIGGERED FINAL IMAGE OR FINAL IMAGE GENERATION ANNOUNCEMENT TO DIGITAL IMAGING DEVICE 10.
IN ADDITION, THE UNIT MAY SAVE AN IMAGE INTO THE FINAL IMAGE MEMORY 80
540
DIGITAL IMAGING DEVICE 10 IS EITHER TAKES A PHOTO (AS PER TRIGGER CONTROL) OR SAVES AND SHOWS THE FINAL IMAGE PLACED IN THE FINAL IMAGE MEMORY 80 BY SELECTED ANALYSIS AND CONTROL UNIT (AS PER FINAL IMAGE GENERATION ANNOUNCEMENT)
545


I ORIGINAL SEQUENCE OF IMAGES
400
410
420
430
440
450
II TIME (IMAGES) TO CROSS
3
2
1
0

III MOMENT ANTICIPATION
SHUTTER BUTTON
TRIGGER
PHOTO
IMAGE 430 IS PHOTOGRAPHED AND SAVED
IMAGE IS SAVED IN 80
IV MOMENT SELECTION
SHUTTER BUTTON
SAVE
SAVE
SAVE
FINAL IMAGE GENERATION ANNOUNCEMENT IS SENT TO 10
V CONVENTIONAL PHOTOGRAPHIC PROCESS
SHUTTER BUTTON
IMAGE 450 IS PHOTOGRAPHED AND SAVED
PHOTO

FIG. 6

FIG. 7

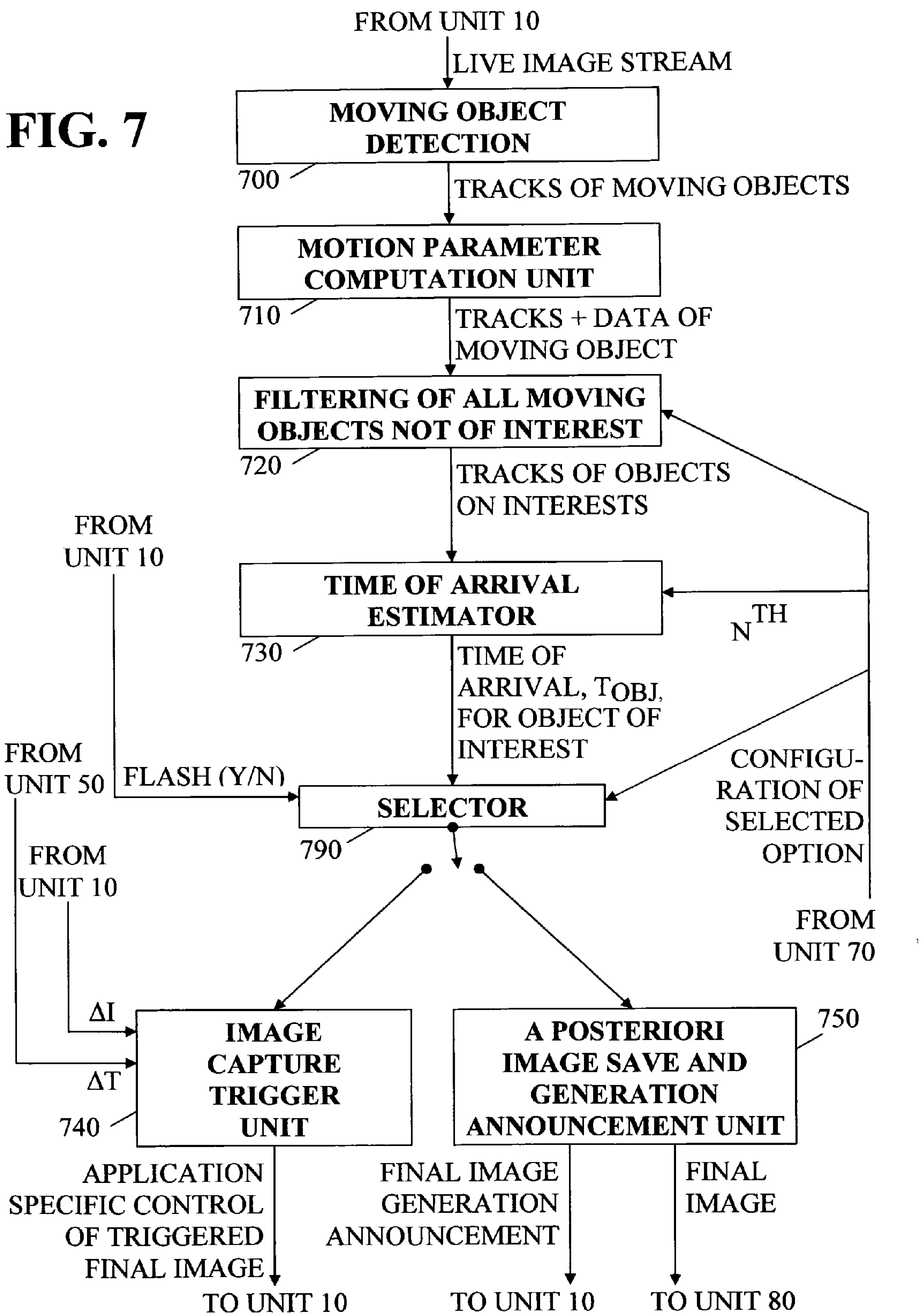

FROM UNIT 10
LIVE IMAGE STREAM
MOVING OBJECT DETECTION
700
TRACKS OF MOVING OBJECTS
MOTION PARAMETER COMPUTATION UNIT
710
TRACKS + DATA OF MOVING OBJECT
FILTERING OF ALL MOVING OBJECTS NOT OF INTEREST
720
TRACKS OF OBJECTS ON INTERESTS
FROM UNIT 10
TIME OF ARRIVAL ESTIMATOR
730
NTH
TIME OF ARRIVAL, TOBJ, FOR OBJECT OF INTEREST
FROM UNIT 50
FLASH (Y/N)
SELECTOR
790
CONFIGURATION OF SELECTED OPTION
FROM UNIT 10
FROM UNIT 70
ΔI
ΔT
IMAGE CAPTURE TRIGGER UNIT
740
A POSTERIORI IMAGE SAVE AND GENERATION ANNOUNCEMENT UNIT
750
APPLICATION SPECIFIC CONTROL OF TRIGGERED FINAL IMAGE
FINAL IMAGE GENERATION ANNOUNCEMENT
FINAL IMAGE
TO UNIT 10
TO UNIT 10
TO UNIT 80

FIG. 8A

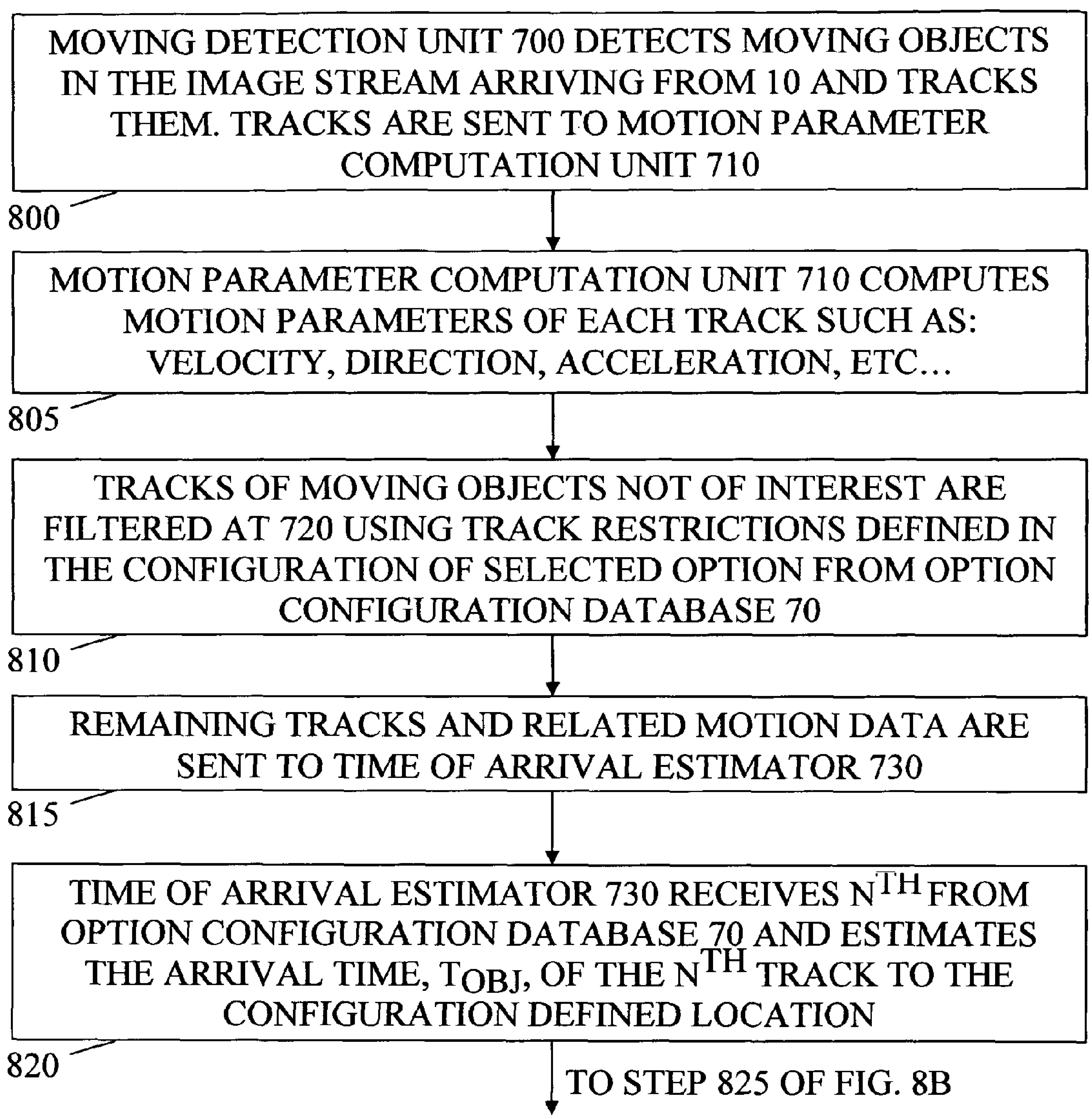

MOVING DETECTION UNIT 700 DETECTS MOVING OBJECTS IN THE IMAGE STREAM ARRIVING FROM 10 AND TRACKS THEM. TRACKS ARE SENT TO MOTION PARAMETER COMPUTATION UNIT 710
800
MOTION PARAMETER COMPUTATION UNIT 710 COMPUTES MOTION PARAMETERS OF EACH TRACK SUCH AS: VELOCITY, DIRECTION, ACCELERATION, ETC…
805
TRACKS OF MOVING OBJECTS NOT OF INTEREST ARE FILTERED AT 720 USING TRACK RESTRICTIONS DEFINED IN THE CONFIGURATION OF SELECTED OPTION FROM OPTION CONFIGURATION DATABASE 70
810
REMAINING TRACKS AND RELATED MOTION DATA ARE SENT TO TIME OF ARRIVAL ESTIMATOR 730
815
TIME OF ARRIVAL ESTIMATOR 730 RECEIVES NTH FROM OPTION CONFIGURATION DATABASE 70 AND ESTIMATES THE ARRIVAL TIME, T_{OBJ}, OF THE NTH TRACK TO THE CONFIGURATION DEFINED LOCATION
820
TO STEP 825 OF FIG. 8B

FIG. 8B

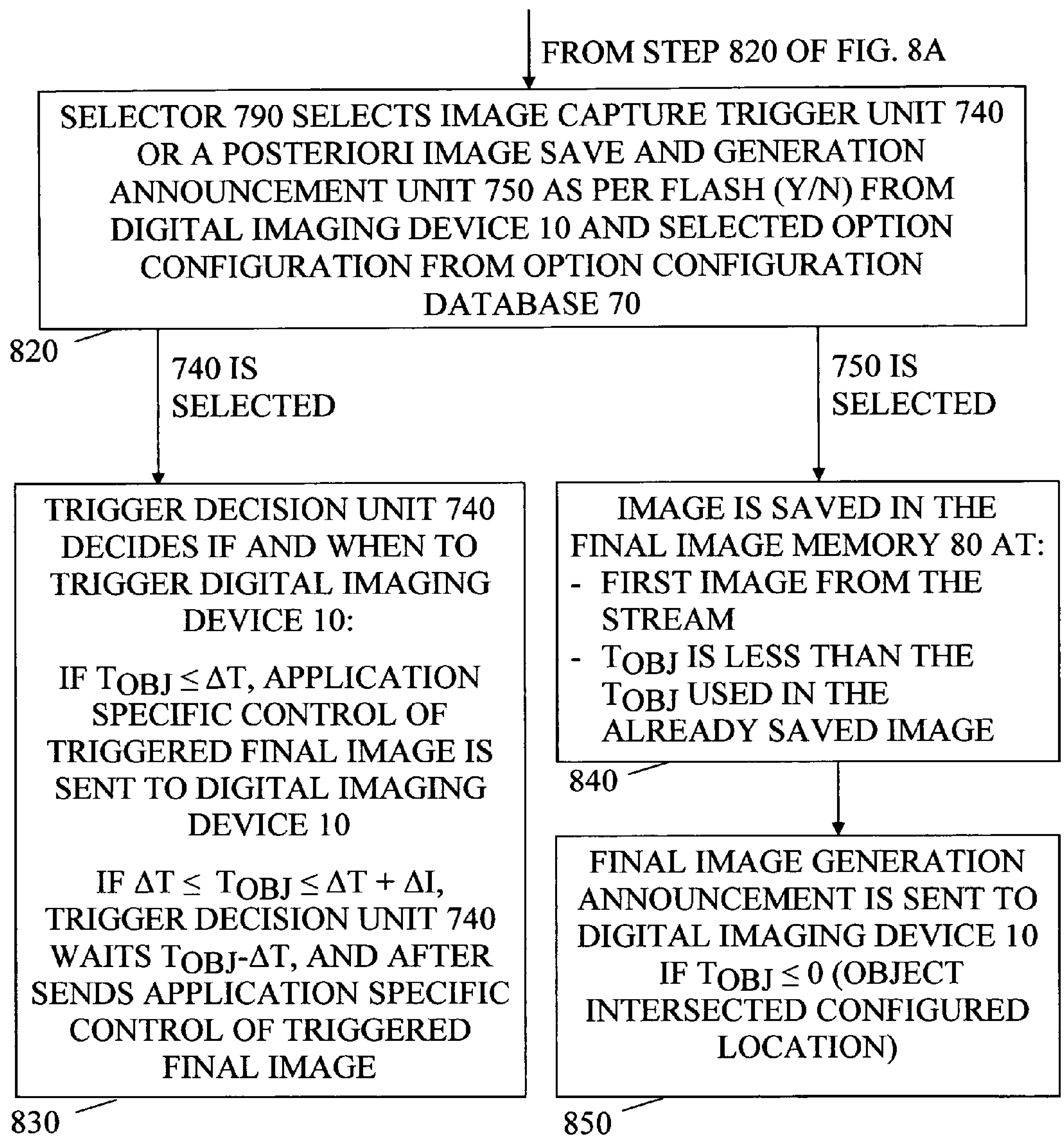

FROM STEP 820 OF FIG. 8A
SELECTOR 790 SELECTS IMAGE CAPTURE TRIGGER UNIT 740 OR A POSTERIORI IMAGE SAVE AND GENERATION ANNOUNCEMENT UNIT 750 AS PER FLASH (Y/N) FROM DIGITAL IMAGING DEVICE 10 AND SELECTED OPTION CONFIGURATION FROM OPTION CONFIGURATION DATABASE 70
820
740 IS SELECTED
750 IS SELECTED
TRIGGER DECISION UNIT 740 DECIDES IF AND WHEN TO TRIGGER DIGITAL IMAGING DEVICE 10:
IF $T_{OBJ} \leq \Delta T$, APPLICATION SPECIFIC CONTROL OF TRIGGERED FINAL IMAGE IS SENT TO DIGITAL IMAGING DEVICE 10
IF $\Delta T \leq T_{OBJ} \leq \Delta T + \Delta I$, TRIGGER DECISION UNIT 740 WAITS $T_{OBJ}-\Delta T$, AND AFTER SENDS APPLICATION SPECIFIC CONTROL OF TRIGGERED FINAL IMAGE
830
IMAGE IS SAVED IN THE FINAL IMAGE MEMORY 80 AT:
- FIRST IMAGE FROM THE STREAM
- T_{OBJ} IS LESS THAN THE T_{OBJ} USED IN THE ALREADY SAVED IMAGE
840
FINAL IMAGE GENERATION ANNOUNCEMENT IS SENT TO DIGITAL IMAGING DEVICE 10 IF $T_{OBJ} \leq 0$ (OBJECT INTERSECTED CONFIGURED LOCATION)
850

FIG. 9A

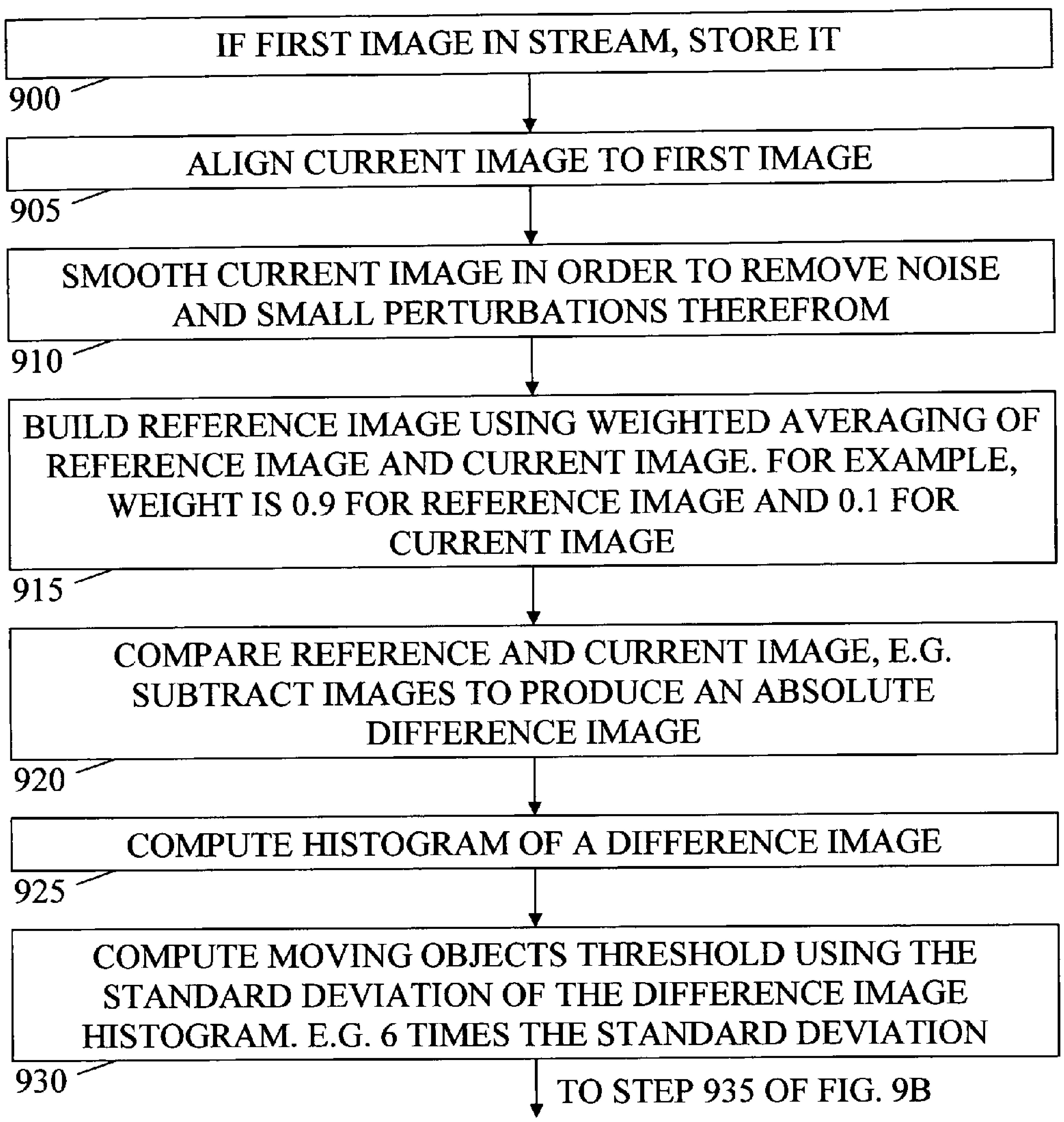

IF FIRST IMAGE IN STREAM, STORE IT
900
ALIGN CURRENT IMAGE TO FIRST IMAGE
905
SMOOTH CURRENT IMAGE IN ORDER TO REMOVE NOISE AND SMALL PERTURBATIONS THEREFROM
910
BUILD REFERENCE IMAGE USING WEIGHTED AVERAGING OF REFERENCE IMAGE AND CURRENT IMAGE. FOR EXAMPLE, WEIGHT IS 0.9 FOR REFERENCE IMAGE AND 0.1 FOR CURRENT IMAGE
915
COMPARE REFERENCE AND CURRENT IMAGE, E.G. SUBTRACT IMAGES TO PRODUCE AN ABSOLUTE DIFFERENCE IMAGE
920
COMPUTE HISTOGRAM OF A DIFFERENCE IMAGE
925
COMPUTE MOVING OBJECTS THRESHOLD USING THE STANDARD DEVIATION OF THE DIFFERENCE IMAGE HISTOGRAM. E.G. 6 TIMES THE STANDARD DEVIATION
930
TO STEP 935 OF FIG. 9B

FIG. 9B

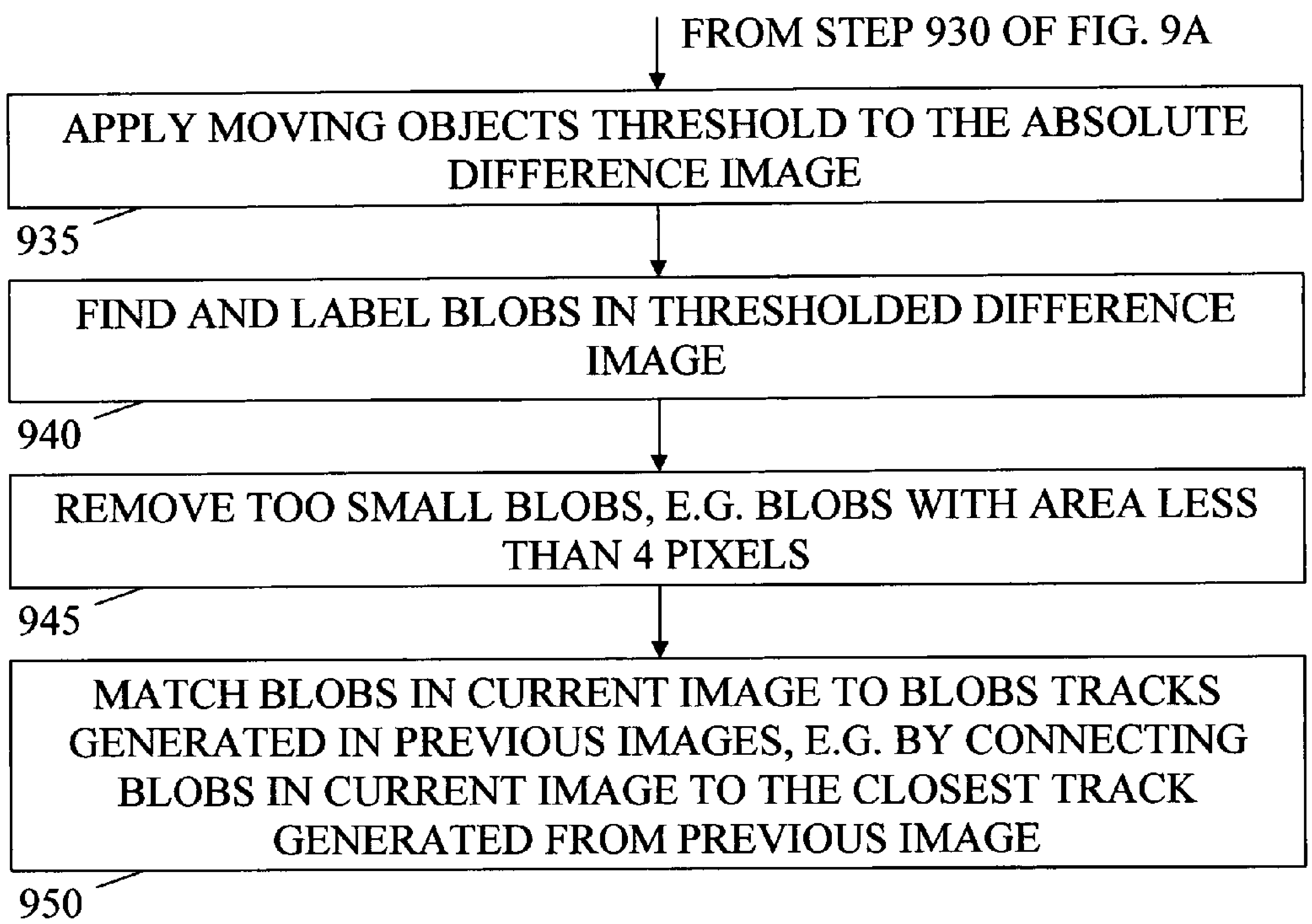

FROM STEP 930 OF FIG. 9A
APPLY MOVING OBJECTS THRESHOLD TO THE ABSOLUTE DIFFERENCE IMAGE
935
FIND AND LABEL BLOBS IN THRESHOLDED DIFFERENCE IMAGE
940
REMOVE TOO SMALL BLOBS, E.G. BLOBS WITH AREA LESS THAN 4 PIXELS
945
MATCH BLOBS IN CURRENT IMAGE TO BLOBS TRACKS GENERATED IN PREVIOUS IMAGES, E.G. BY CONNECTING BLOBS IN CURRENT IMAGE TO THE CLOSEST TRACK GENERATED FROM PREVIOUS IMAGE
950

FIG. 10

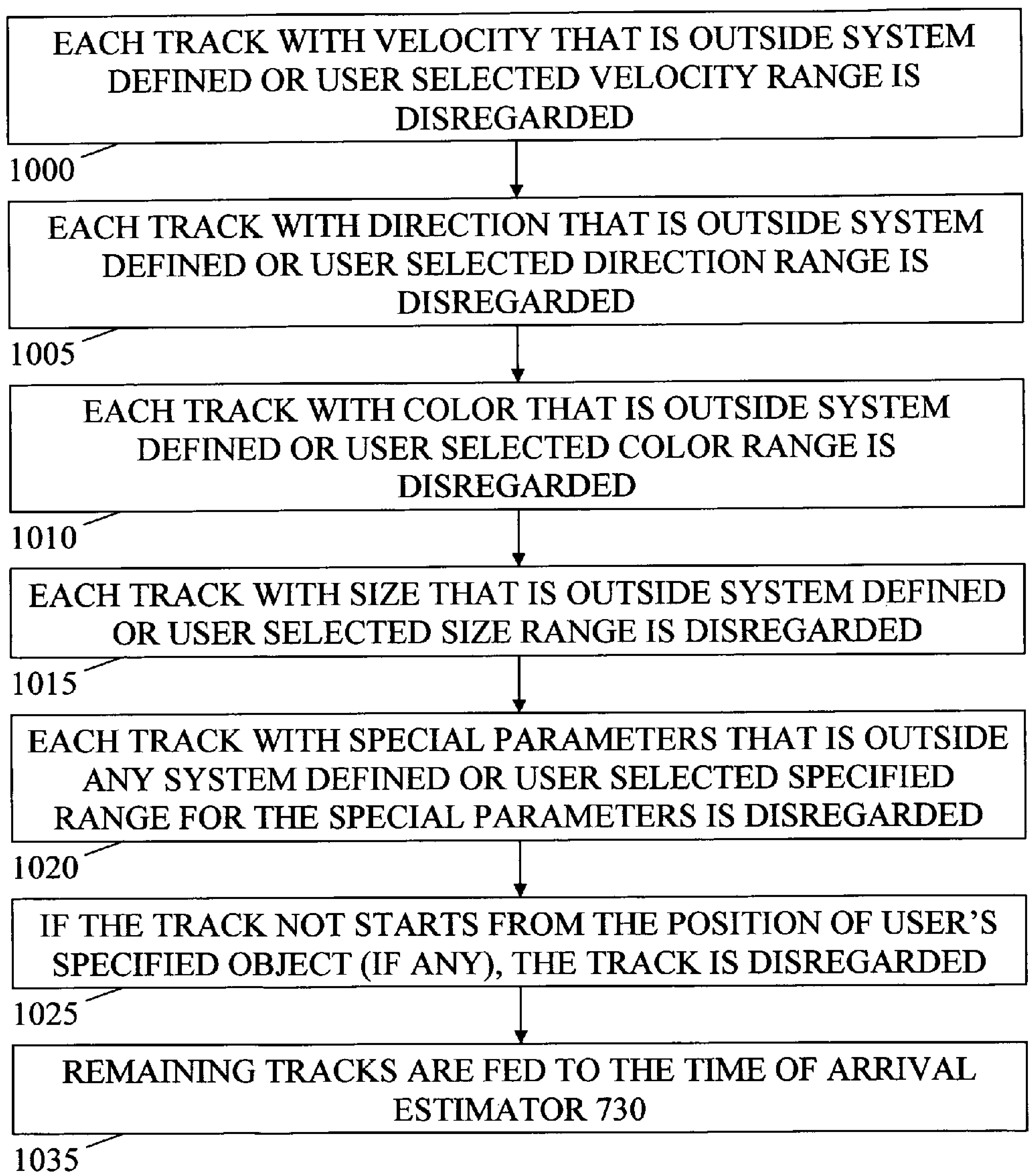

EACH TRACK WITH VELOCITY THAT IS OUTSIDE SYSTEM DEFINED OR USER SELECTED VELOCITY RANGE IS DISREGARDED
1000
EACH TRACK WITH DIRECTION THAT IS OUTSIDE SYSTEM DEFINED OR USER SELECTED DIRECTION RANGE IS DISREGARDED
1005
EACH TRACK WITH COLOR THAT IS OUTSIDE SYSTEM DEFINED OR USER SELECTED COLOR RANGE IS DISREGARDED
1010
EACH TRACK WITH SIZE THAT IS OUTSIDE SYSTEM DEFINED OR USER SELECTED SIZE RANGE IS DISREGARDED
1015
EACH TRACK WITH SPECIAL PARAMETERS THAT IS OUTSIDE ANY SYSTEM DEFINED OR USER SELECTED SPECIFIED RANGE FOR THE SPECIAL PARAMETERS IS DISREGARDED
1020
IF THE TRACK NOT STARTS FROM THE POSITION OF USER'S SPECIFIED OBJECT (IF ANY), THE TRACK IS DISREGARDED
1025
REMAINING TRACKS ARE FED TO THE TIME OF ARRIVAL ESTIMATOR 730
1035

FIG. 11

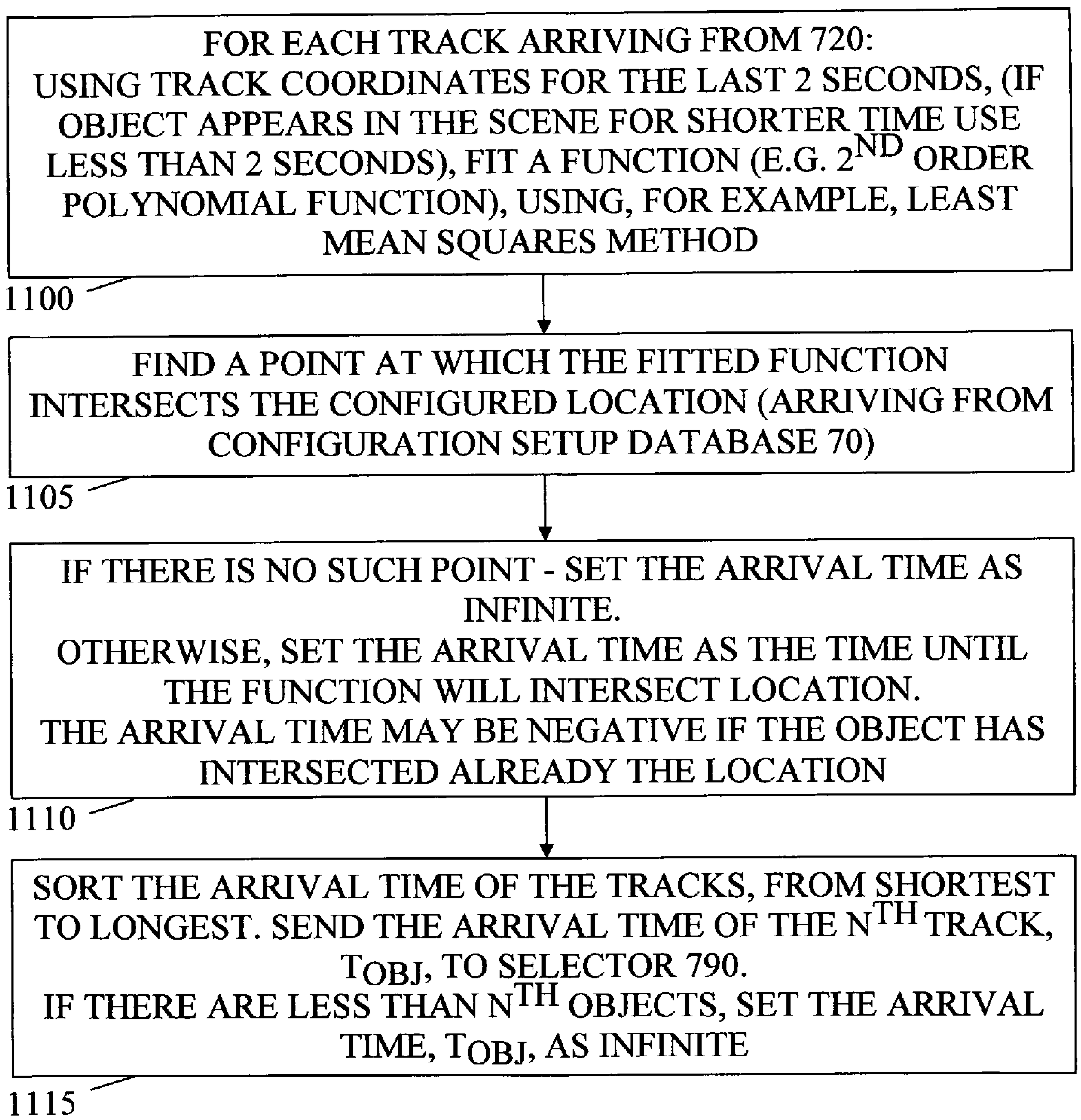
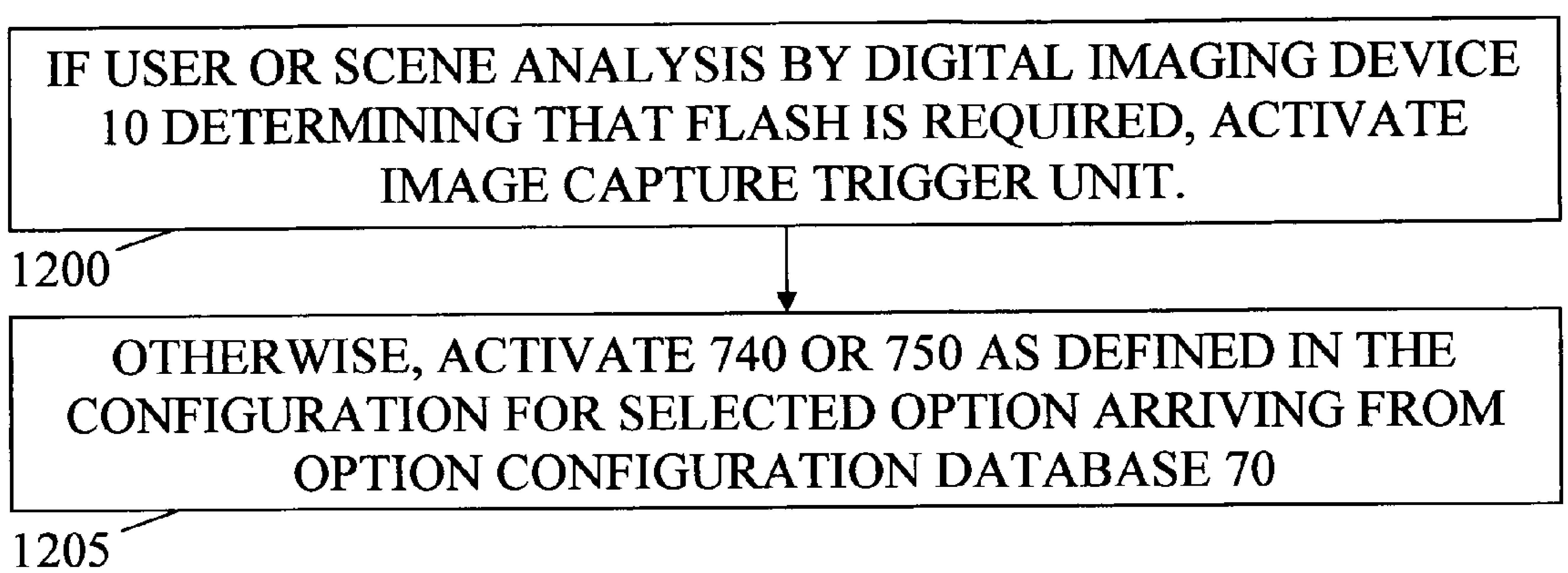

FOR EACH TRACK ARRIVING FROM 720:
USING TRACK COORDINATES FOR THE LAST 2 SECONDS, (IF OBJECT APPEARS IN THE SCENE FOR SHORTER TIME USE LESS THAN 2 SECONDS), FIT A FUNCTION (E.G. 2ND ORDER POLYNOMIAL FUNCTION), USING, FOR EXAMPLE, LEAST MEAN SQUARES METHOD
1100
FIND A POINT AT WHICH THE FITTED FUNCTION INTERSECTS THE CONFIGURED LOCATION (ARRIVING FROM CONFIGURATION SETUP DATABASE 70)
1105
IF THERE IS NO SUCH POINT - SET THE ARRIVAL TIME AS INFINITE.
OTHERWISE, SET THE ARRIVAL TIME AS THE TIME UNTIL THE FUNCTION WILL INTERSECT LOCATION.
THE ARRIVAL TIME MAY BE NEGATIVE IF THE OBJECT HAS INTERSECTED ALREADY THE LOCATION
1110
SORT THE ARRIVAL TIME OF THE TRACKS, FROM SHORTEST TO LONGEST. SEND THE ARRIVAL TIME OF THE NTH TRACK, TOBJ, TO SELECTOR 790.
IF THERE ARE LESS THAN NTH OBJECTS, SET THE ARRIVAL TIME, TOBJ, AS INFINITE
1115

FIG. 12


IF USER OR SCENE ANALYSIS BY DIGITAL IMAGING DEVICE 10 DETERMINING THAT FLASH IS REQUIRED, ACTIVATE IMAGE CAPTURE TRIGGER UNIT.
1200
OTHERWISE, ACTIVATE 740 OR 750 AS DEFINED IN THE CONFIGURATION FOR SELECTED OPTION ARRIVING FROM OPTION CONFIGURATION DATABASE 70
1205

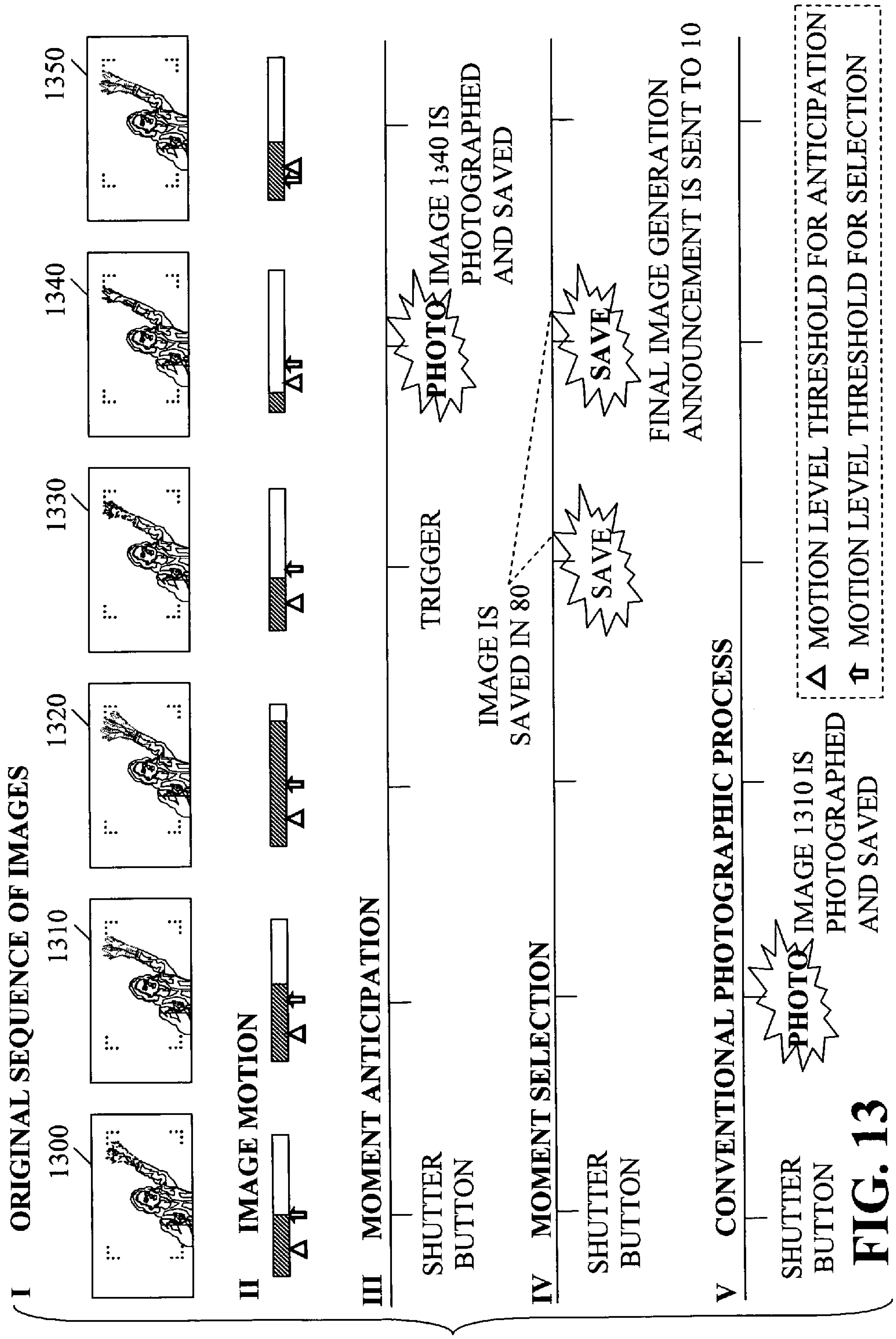
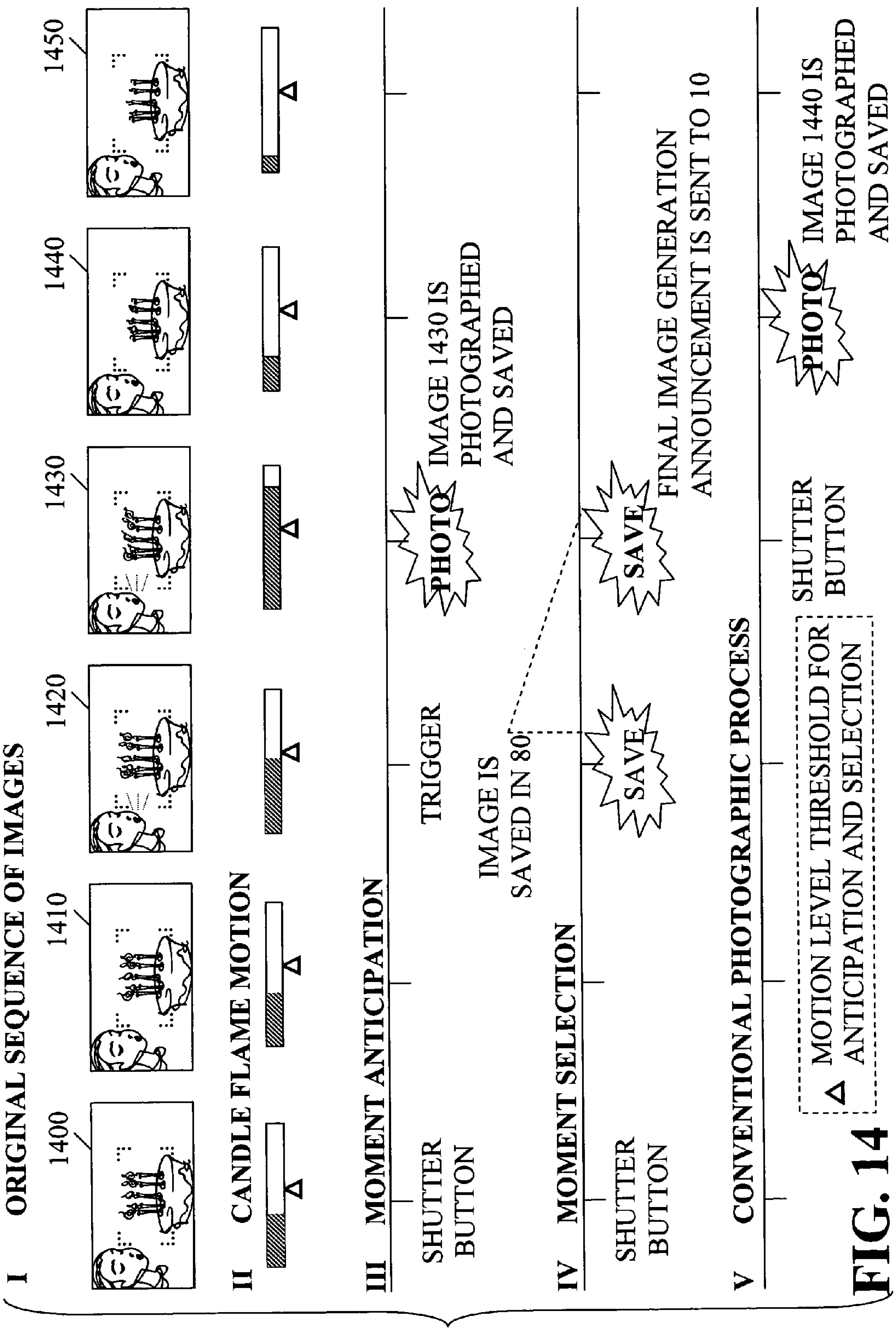

I ORIGINAL SEQUENCE OF IMAGES
1300
1310
1320
1330
1340
1350
II IMAGE MOTION
III MOMENT ANTICIPATION
SHUTTER BUTTON
TRIGGER
PHOTO
IMAGE 1340 IS PHOTOGRAPHED AND SAVED
IV MOMENT SELECTION
SHUTTER BUTTON
IMAGE IS SAVED IN 80
SAVE
SAVE
FINAL IMAGE GENERATION ANNOUNCEMENT IS SENT TO 10
V CONVENTIONAL PHOTOGRAPHIC PROCESS
SHUTTER BUTTON
PHOTO
IMAGE 1310 IS PHOTOGRAPHED AND SAVED
MOTION LEVEL THRESHOLD FOR ANTICIPATION
MOTION LEVEL THRESHOLD FOR SELECTION

FIG. 13



I ORIGINAL SEQUENCE OF IMAGES
1400
1410
1420
1430
1440
1450
II CANDLE FLAME MOTION
III MOMENT ANTICIPATION
SHUTTER BUTTON
TRIGGER
PHOTO
IMAGE 1430 IS PHOTOGRAPHED AND SAVED
IMAGE IS SAVED IN 80
IV MOMENT SELECTION
SHUTTER BUTTON
SAVE
SAVE
FINAL IMAGE GENERATION ANNOUNCEMENT IS SENT TO 10
V CONVENTIONAL PHOTOGRAPHIC PROCESS
SHUTTER BUTTON
PHOTO
IMAGE 1440 IS PHOTOGRAPHED AND SAVED
MOTION LEVEL THRESHOLD FOR ANTICIPATION AND SELECTION

FIG. 14

FIG. 15

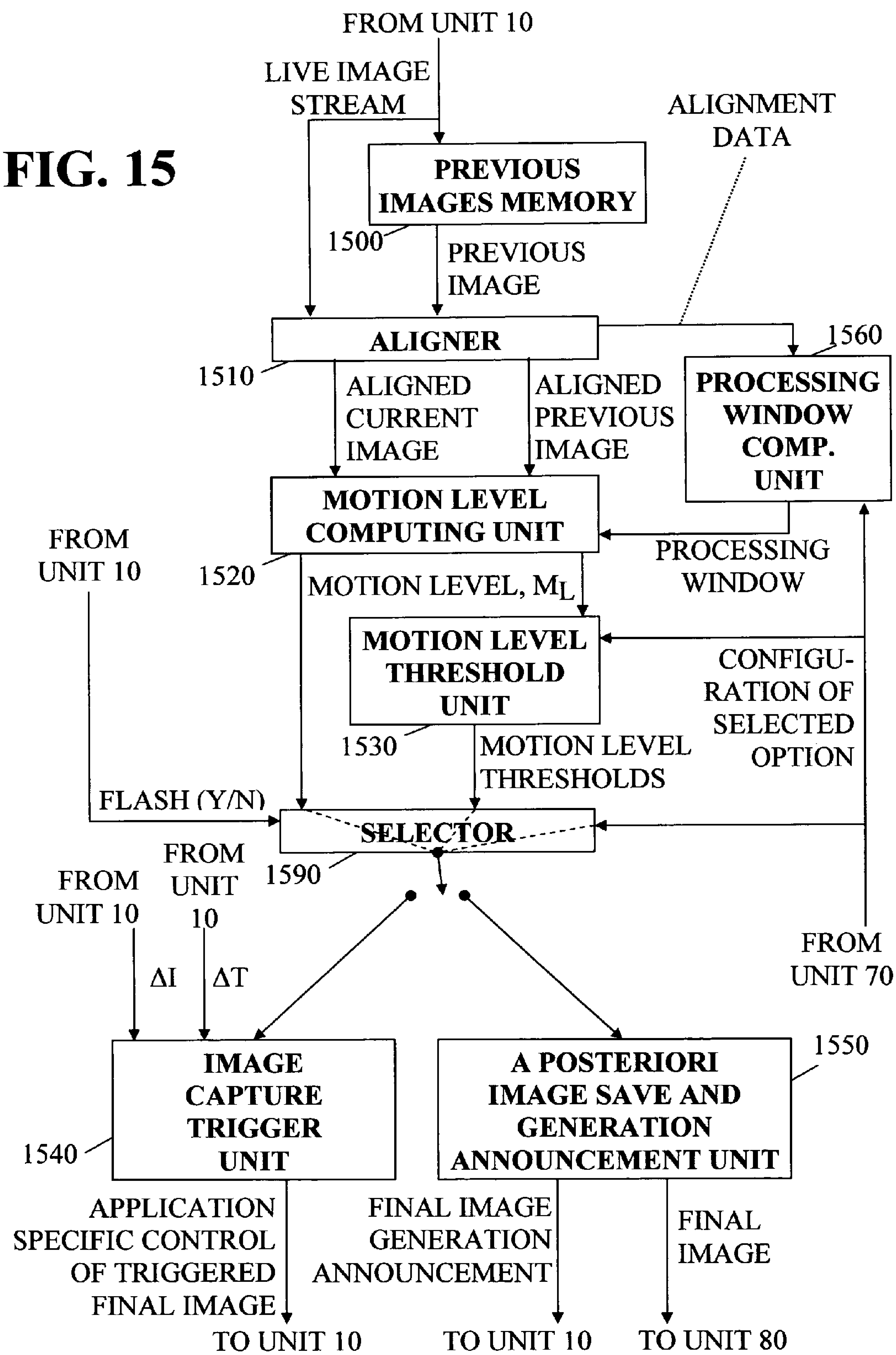
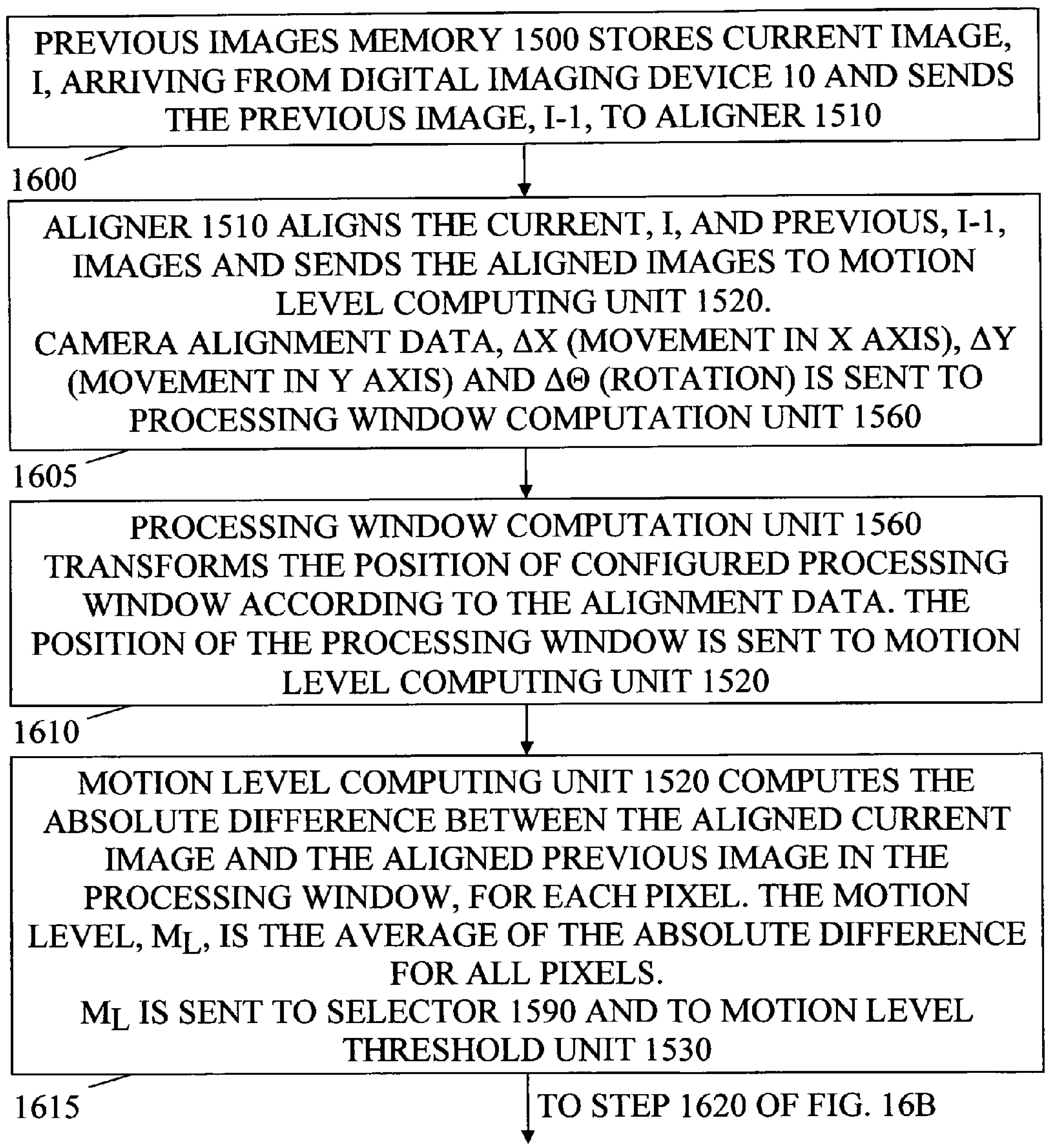

FROM UNIT 10
LIVE IMAGE STREAM
ALIGNMENT DATA
PREVIOUS IMAGES MEMORY
1500
PREVIOUS IMAGE
ALIGNER
1560
1510
ALIGNED CURRENT IMAGE
ALIGNED PREVIOUS IMAGE
PROCESSING WINDOW COMP. UNIT
MOTION LEVEL COMPUTING UNIT
FROM UNIT 10
1520
PROCESSING WINDOW
MOTION LEVEL, M_L
MOTION LEVEL THRESHOLD UNIT
CONFIGU-RATION OF SELECTED OPTION
1530
MOTION LEVEL THRESHOLDS
FLASH (Y/N)
SELECTOR
FROM UNIT 10
FROM UNIT 10
1590
FROM UNIT 70
ΔI
ΔT
IMAGE CAPTURE TRIGGER UNIT
A POSTERIORI IMAGE SAVE AND GENERATION ANNOUNCEMENT UNIT
1550
1540
APPLICATION SPECIFIC CONTROL OF TRIGGERED FINAL IMAGE
FINAL IMAGE GENERATION ANNOUNCEMENT
FINAL IMAGE
TO UNIT 10
TO UNIT 10
TO UNIT 80

FIG. 16A


PREVIOUS IMAGES MEMORY 1500 STORES CURRENT IMAGE, I, ARRIVING FROM DIGITAL IMAGING DEVICE 10 AND SENDS THE PREVIOUS IMAGE, I-1, TO ALIGNER 1510
1600
ALIGNER 1510 ALIGNS THE CURRENT, I, AND PREVIOUS, I-1, IMAGES AND SENDS THE ALIGNED IMAGES TO MOTION LEVEL COMPUTING UNIT 1520.
CAMERA ALIGNMENT DATA, ΔX (MOVEMENT IN X AXIS), ΔY (MOVEMENT IN Y AXIS) AND ΔΘ (ROTATION) IS SENT TO PROCESSING WINDOW COMPUTATION UNIT 1560
1605
PROCESSING WINDOW COMPUTATION UNIT 1560 TRANSFORMS THE POSITION OF CONFIGURED PROCESSING WINDOW ACCORDING TO THE ALIGNMENT DATA. THE POSITION OF THE PROCESSING WINDOW IS SENT TO MOTION LEVEL COMPUTING UNIT 1520
1610
MOTION LEVEL COMPUTING UNIT 1520 COMPUTES THE ABSOLUTE DIFFERENCE BETWEEN THE ALIGNED CURRENT IMAGE AND THE ALIGNED PREVIOUS IMAGE IN THE PROCESSING WINDOW, FOR EACH PIXEL. THE MOTION LEVEL, M_L, IS THE AVERAGE OF THE ABSOLUTE DIFFERENCE FOR ALL PIXELS.
M_L IS SENT TO SELECTOR 1590 AND TO MOTION LEVEL THRESHOLD UNIT 1530
1615
TO STEP 1620 OF FIG. 16B

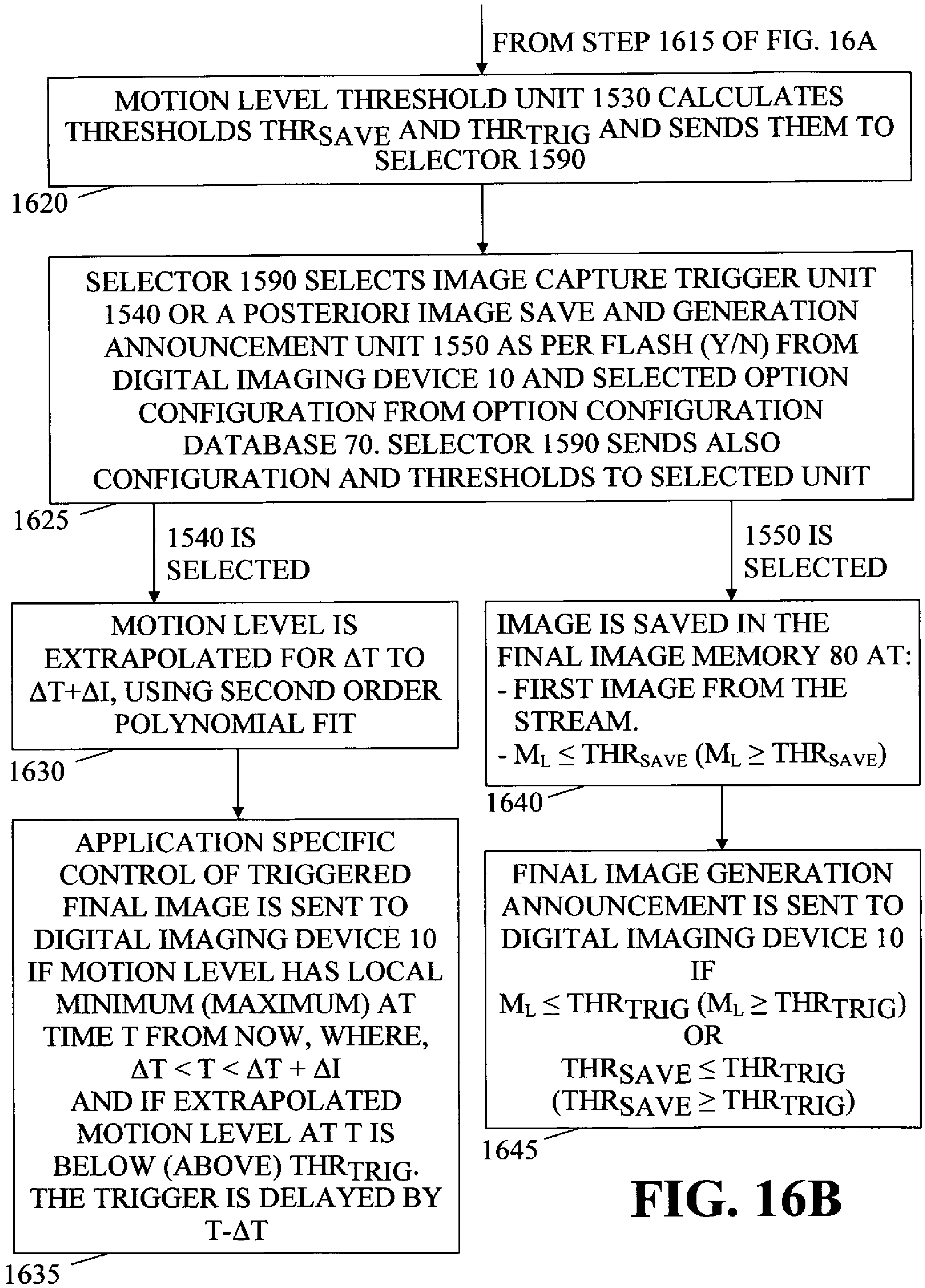

FROM STEP 1615 OF FIG. 16A
MOTION LEVEL THRESHOLD UNIT 1530 CALCULATES THRESHOLDS THR_{SAVE} AND THR_{TRIG} AND SENDS THEM TO SELECTOR 1590
1620
SELECTOR 1590 SELECTS IMAGE CAPTURE TRIGGER UNIT 1540 OR A POSTERIORI IMAGE SAVE AND GENERATION ANNOUNCEMENT UNIT 1550 AS PER FLASH (Y/N) FROM DIGITAL IMAGING DEVICE 10 AND SELECTED OPTION CONFIGURATION FROM OPTION CONFIGURATION DATABASE 70. SELECTOR 1590 SENDS ALSO CONFIGURATION AND THRESHOLDS TO SELECTED UNIT
1625
1540 IS SELECTED
1550 IS SELECTED
MOTION LEVEL IS EXTRAPOLATED FOR ΔT TO $\Delta T+\Delta I$, USING SECOND ORDER POLYNOMIAL FIT
1630
IMAGE IS SAVED IN THE FINAL IMAGE MEMORY 80 AT:
- FIRST IMAGE FROM THE STREAM.
- $M_L \leq THR_{SAVE}$ ($M_L \geq THR_{SAVE}$)
1640
APPLICATION SPECIFIC CONTROL OF TRIGGERED FINAL IMAGE IS SENT TO DIGITAL IMAGING DEVICE 10 IF MOTION LEVEL HAS LOCAL MINIMUM (MAXIMUM) AT TIME T FROM NOW, WHERE, $\Delta T < T < \Delta T + \Delta I$ AND IF EXTRAPOLATED MOTION LEVEL AT T IS BELOW (ABOVE) THR_{TRIG}. THE TRIGGER IS DELAYED BY $T-\Delta T$
1635
FINAL IMAGE GENERATION ANNOUNCEMENT IS SENT TO DIGITAL IMAGING DEVICE 10 IF $M_L \leq THR_{TRIG}$ ($M_L \geq THR_{TRIG}$) OR $THR_{SAVE} \leq THR_{TRIG}$ ($THR_{SAVE} \geq THR_{TRIG}$)
1645

FIG. 16B

FIG. 17

RECEIVE MOTION LEVEL, M_L, FROM MOTION LEVEL COMMUTATING UNIT 1520

1700

COMPUTE STATISTICS ON THE MOTION LEVEL:
- AVERAGE - μ_{MOTION}
- STANDARD DEVIATION - STD_{MOTION}
- MINIMUM - MIN_{MOTION} (MAXIMUM - MAX_{MOTION})

1705

ASSIGN MIN_{MOTION} (MAX_{MOTION}) AS THR_{SAVE}

1710

IF THE STATISTICS IN STEP 1700 IS NOT RELIABLE YET (E.G. BEFORE 5 IMAGES OR 1 SECOND), SET MOTION LEVEL THRESHOLD, THR_{TRIG}, AS ZERO (INFINITE) AND EXIT.

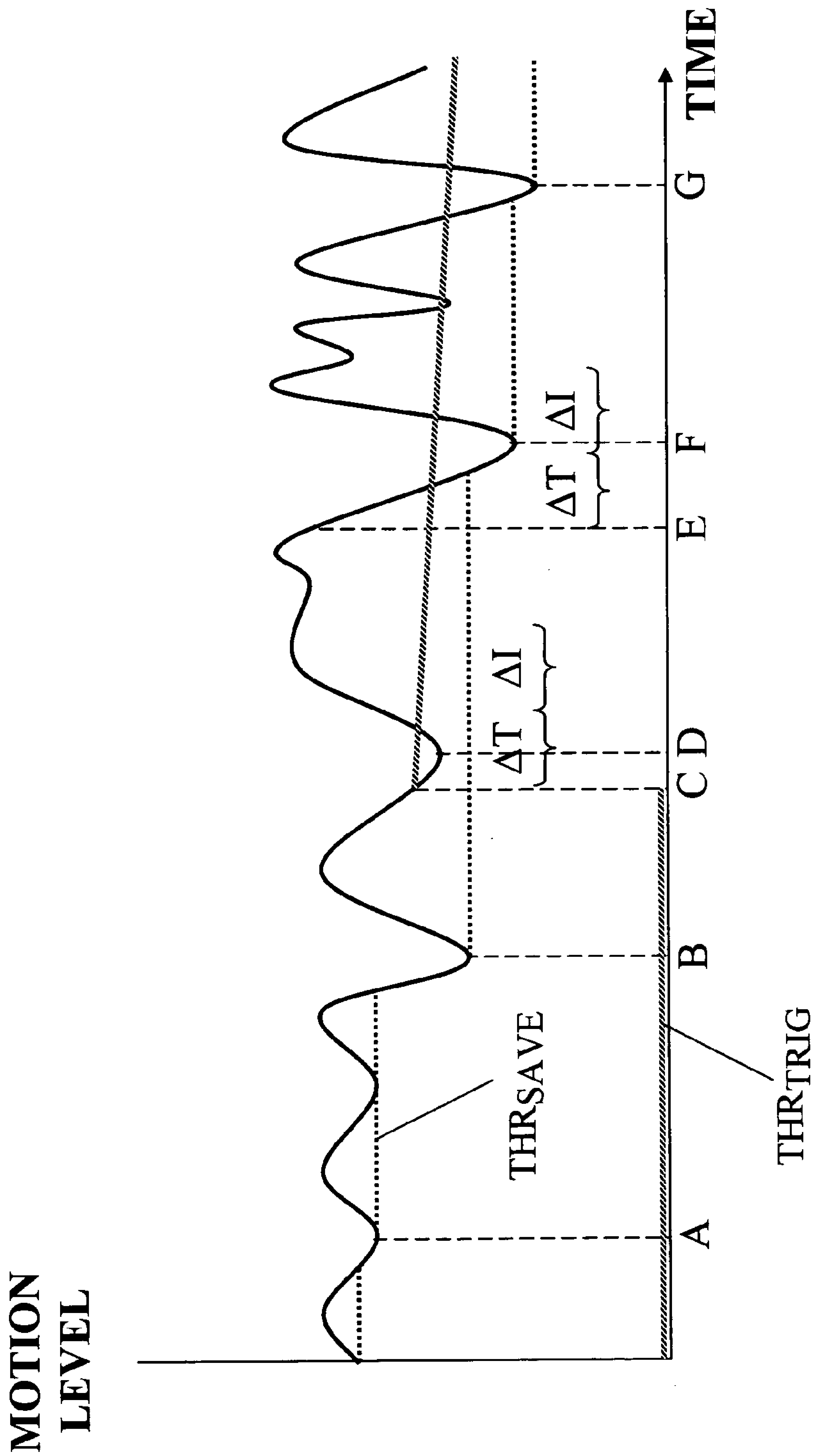
IN SUCH CASE IMAGE CAPTURE TRIGGER UNIT 1540 WILL NOT SENT APPLICATION SPECIFIC CONTROL OF TRIGGERED FINAL IMAGE AND A POSTERIORI IMAGE SAVE AND GENERATION ANNOUNCEMENT UNIT 1550 WILL NOT SEND FINAL IMAGE GENERATION ANNOUNCEMENT

1715

COMPUTE THR_{TRIG} AS MINIMUM (MAXIMUM) OF:
- μ_{MOTION} – CONST * STD_{MOTION} (μ_{MOTION} + CONST * STD_{MOTION}) CONST IN DEFINED AT OPTION CONFIGURATION DATABASE 70
- MIN_{MOTION} (MAX_{MOTION})
- MOTION LEVEL CONSTANT THRESHOLD DEFINED AT OPTION CONFIGURATION DATABASE 70

1720

FIG. 18



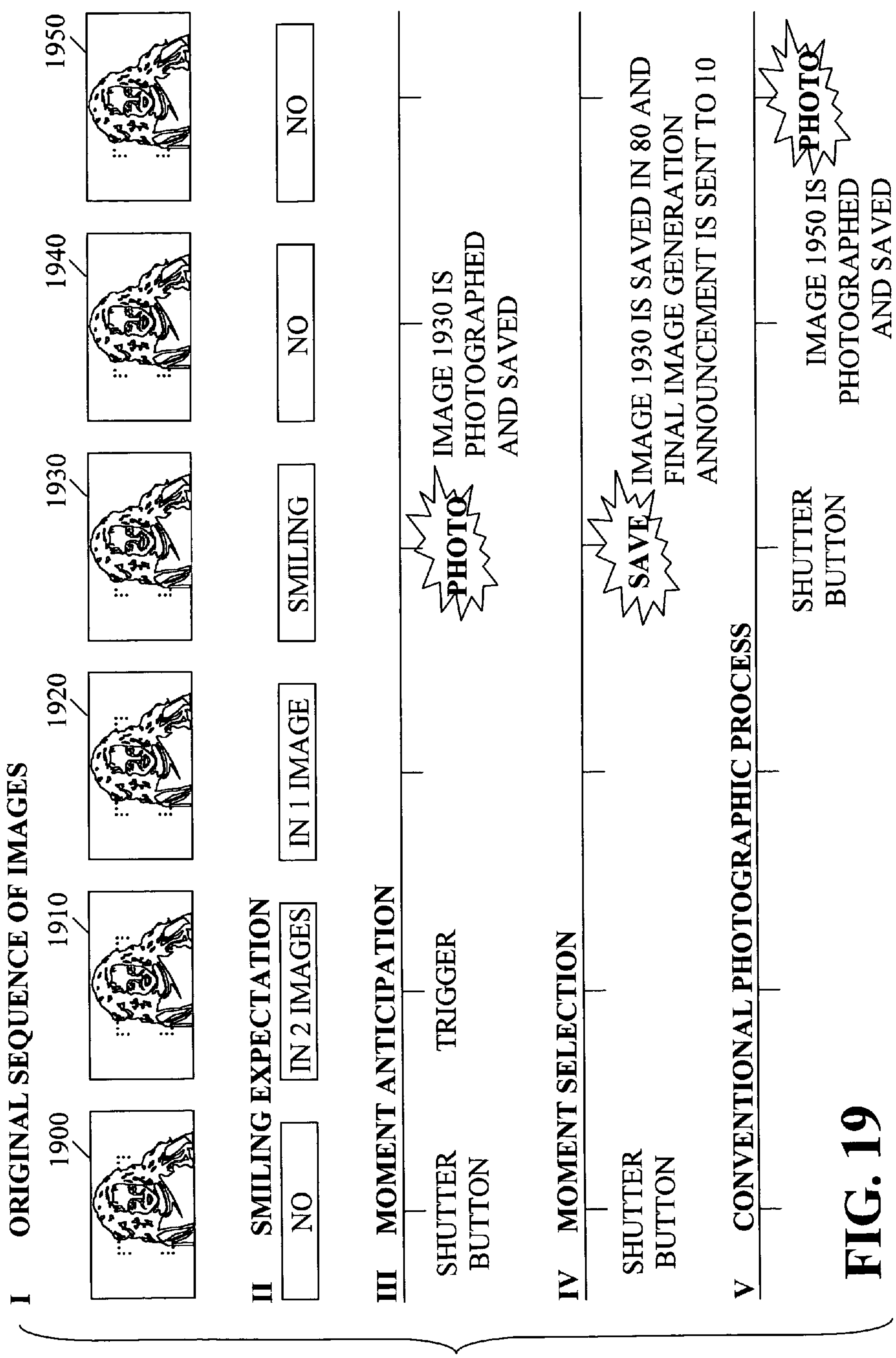
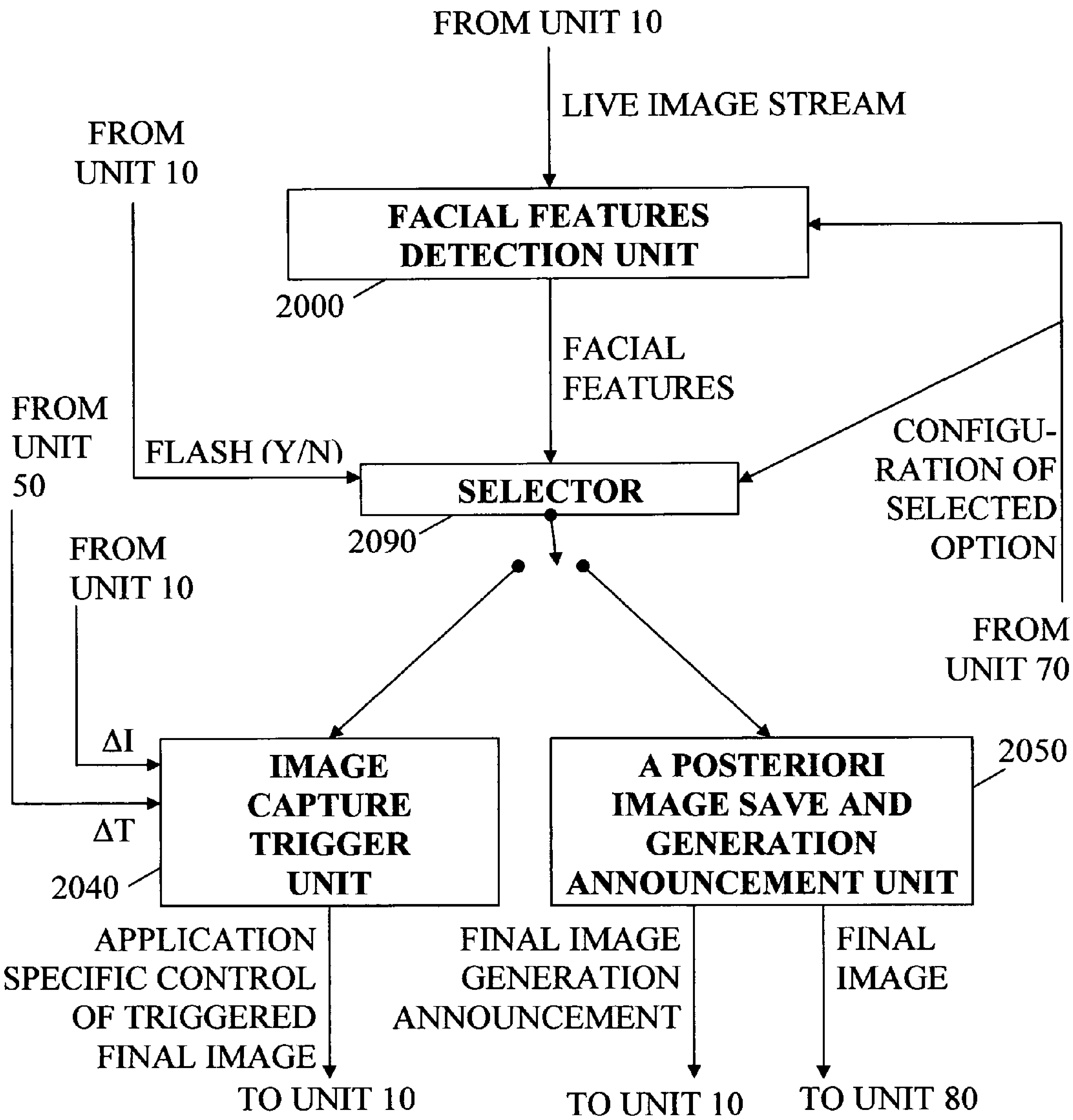

I ORIGINAL SEQUENCE OF IMAGES
1900
1910
1920
1930
1940
1950
II SMILING EXPECTATION
NO
IN 2 IMAGES
IN 1 IMAGE
SMILING
NO
NO
III MOMENT ANTICIPATION
SHUTTER BUTTON
TRIGGER
PHOTO
IMAGE 1930 IS PHOTOGRAPHED AND SAVED
IV MOMENT SELECTION
SHUTTER BUTTON
SAVE
IMAGE 1930 IS SAVED IN 80 AND FINAL IMAGE GENERATION ANNOUNCEMENT IS SENT TO 10
V CONVENTIONAL PHOTOGRAPHIC PROCESS
SHUTTER BUTTON
IMAGE 1950 IS PHOTOGRAPHED AND SAVED
PHOTO

FIG. 19

FIG. 20


FROM UNIT 10
LIVE IMAGE STREAM
FROM UNIT 10
FACIAL FEATURES DETECTION UNIT
2000
FACIAL FEATURES
FROM UNIT 50
FLASH (Y/N)
SELECTOR
2090
CONFIGURATION OF SELECTED OPTION
FROM UNIT 10
FROM UNIT 70
ΔI
ΔT
IMAGE CAPTURE TRIGGER UNIT
2040
A POSTERIORI IMAGE SAVE AND GENERATION ANNOUNCEMENT UNIT
2050
APPLICATION SPECIFIC CONTROL OF TRIGGERED FINAL IMAGE
FINAL IMAGE GENERATION ANNOUNCEMENT
FINAL IMAGE
TO UNIT 10
TO UNIT 10
TO UNIT 80

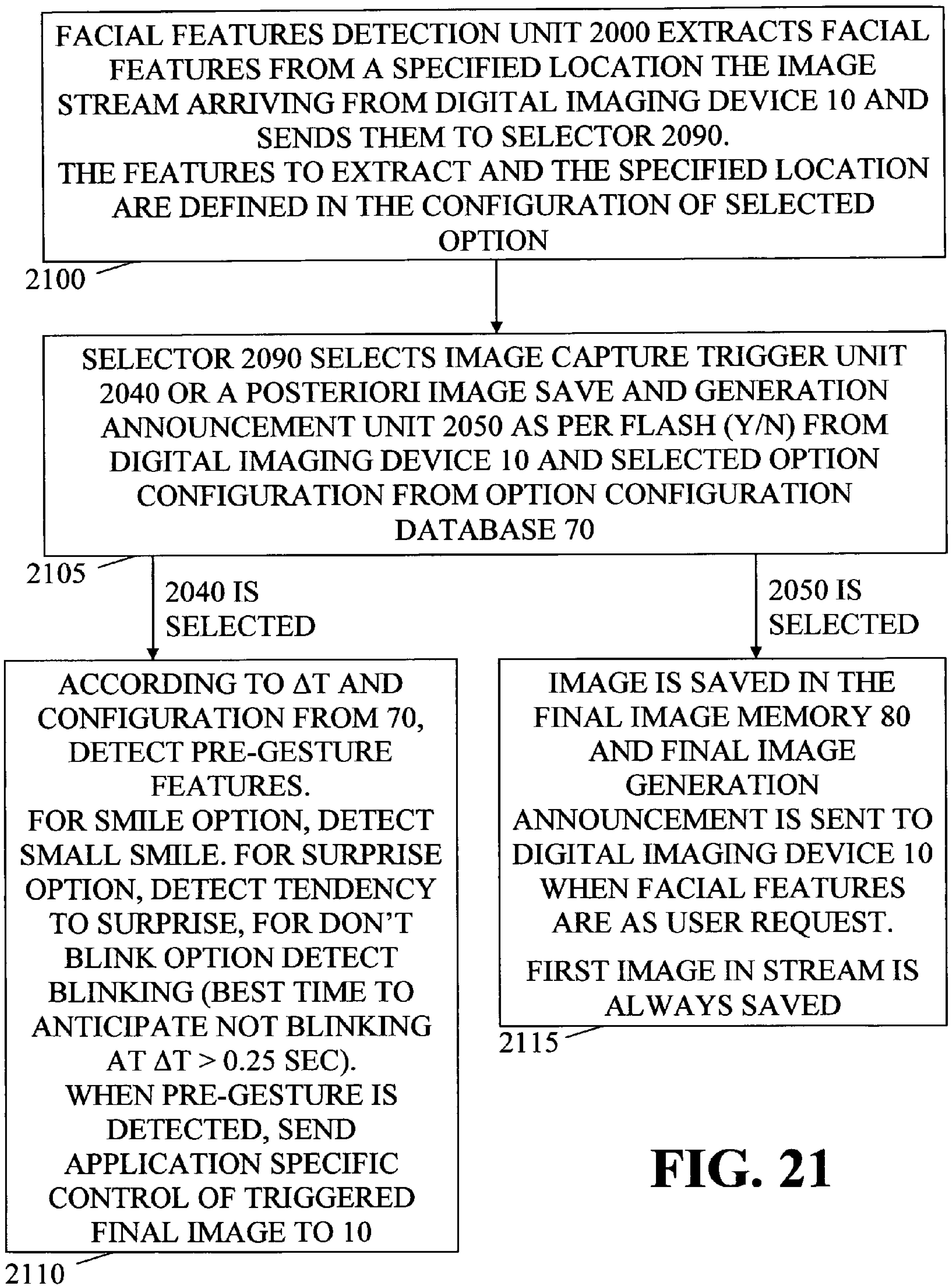

FACIAL FEATURES DETECTION UNIT 2000 EXTRACTS FACIAL FEATURES FROM A SPECIFIED LOCATION THE IMAGE STREAM ARRIVING FROM DIGITAL IMAGING DEVICE 10 AND SENDS THEM TO SELECTOR 2090.
THE FEATURES TO EXTRACT AND THE SPECIFIED LOCATION ARE DEFINED IN THE CONFIGURATION OF SELECTED OPTION
2100
SELECTOR 2090 SELECTS IMAGE CAPTURE TRIGGER UNIT 2040 OR A POSTERIORI IMAGE SAVE AND GENERATION ANNOUNCEMENT UNIT 2050 AS PER FLASH (Y/N) FROM DIGITAL IMAGING DEVICE 10 AND SELECTED OPTION CONFIGURATION FROM OPTION CONFIGURATION DATABASE 70
2105
2040 IS SELECTED
2050 IS SELECTED
ACCORDING TO ΔT AND CONFIGURATION FROM 70, DETECT PRE-GESTURE FEATURES.
FOR SMILE OPTION, DETECT SMALL SMILE. FOR SURPRISE OPTION, DETECT TENDENCY TO SURPRISE, FOR DON'T BLINK OPTION DETECT BLINKING (BEST TIME TO ANTICIPATE NOT BLINKING AT ΔT > 0.25 SEC).
WHEN PRE-GESTURE IS DETECTED, SEND APPLICATION SPECIFIC CONTROL OF TRIGGERED FINAL IMAGE TO 10
2110
IMAGE IS SAVED IN THE FINAL IMAGE MEMORY 80 AND FINAL IMAGE GENERATION ANNOUNCEMENT IS SENT TO DIGITAL IMAGING DEVICE 10 WHEN FACIAL FEATURES ARE AS USER REQUEST.
FIRST IMAGE IN STREAM IS ALWAYS SAVED
2115

FIG. 21

FIG. 22

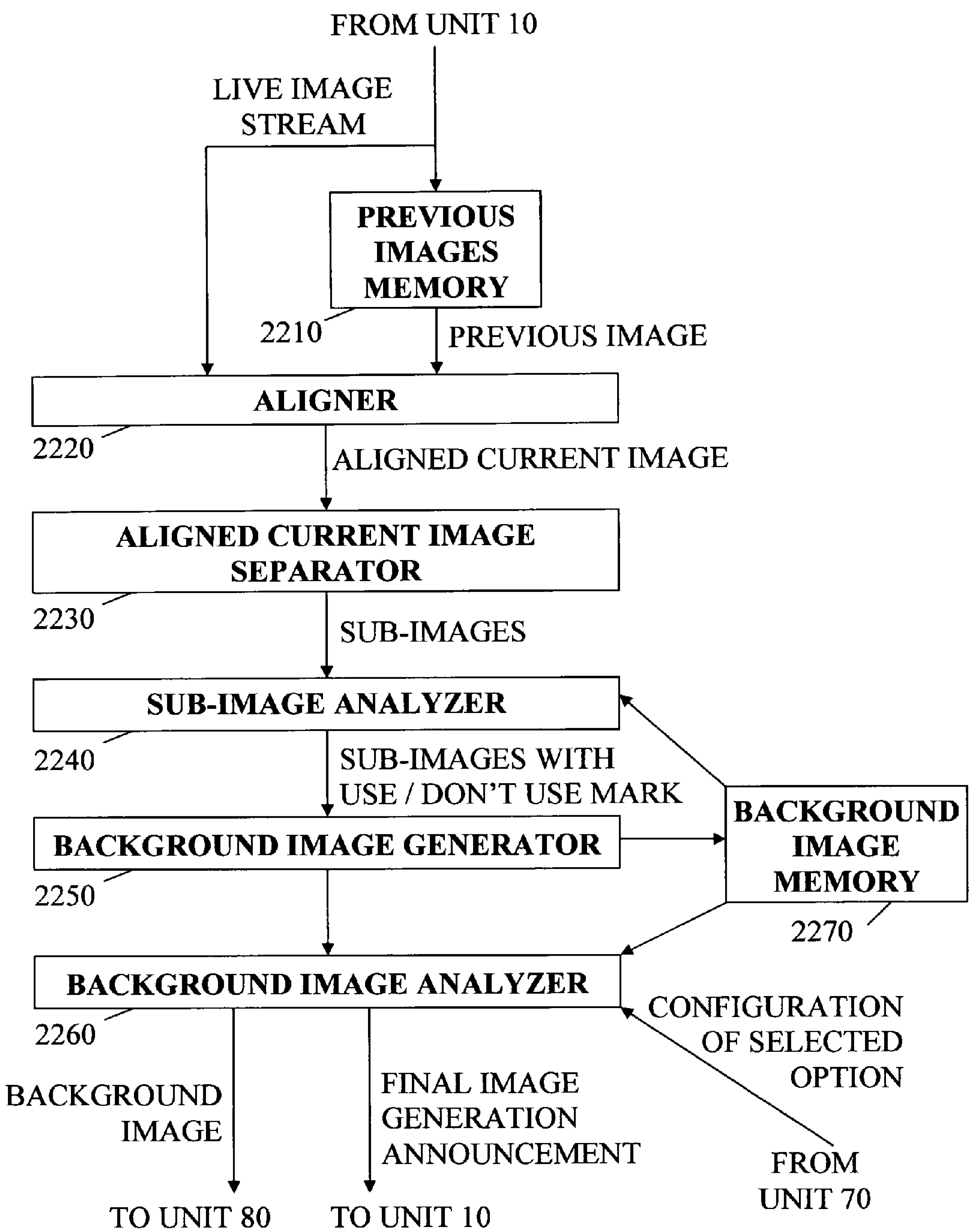

FROM UNIT 10
LIVE IMAGE STREAM
PREVIOUS IMAGES MEMORY
2210
PREVIOUS IMAGE
ALIGNER
2220
ALIGNED CURRENT IMAGE
ALIGNED CURRENT IMAGE SEPARATOR
2230
SUB-IMAGES
SUB-IMAGE ANALYZER
2240
SUB-IMAGES WITH USE / DON'T USE MARK
BACKGROUND IMAGE GENERATOR
2250
BACKGROUND IMAGE MEMORY
2270
BACKGROUND IMAGE ANALYZER
2260
CONFIGURATION OF SELECTED OPTION
BACKGROUND IMAGE
FINAL IMAGE GENERATION ANNOUNCEMENT
FROM UNIT 70
TO UNIT 80
TO UNIT 10

FIG. 23A

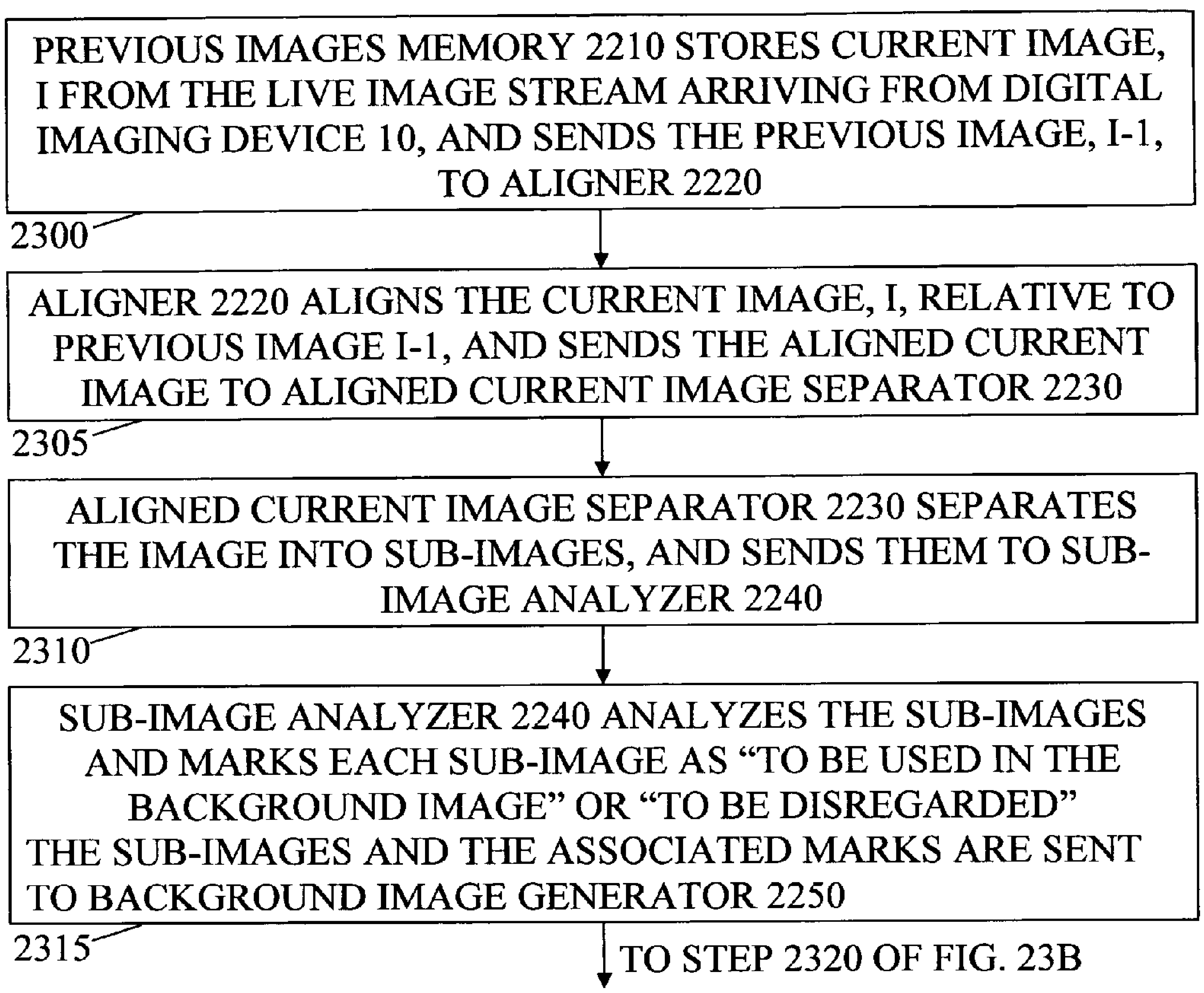
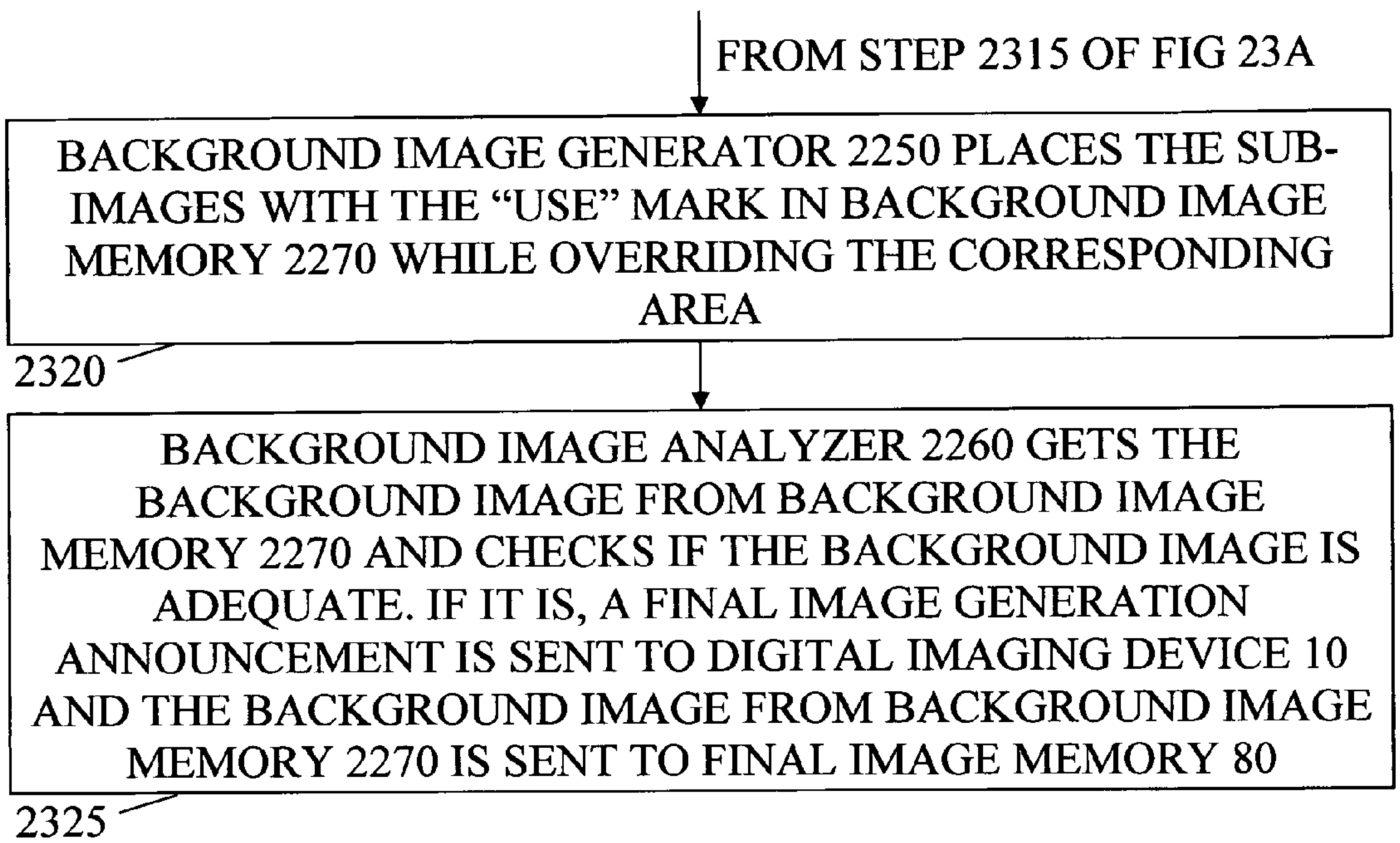

PREVIOUS IMAGES MEMORY 2210 STORES CURRENT IMAGE, I FROM THE LIVE IMAGE STREAM ARRIVING FROM DIGITAL IMAGING DEVICE 10, AND SENDS THE PREVIOUS IMAGE, I-1, TO ALIGNER 2220
2300
ALIGNER 2220 ALIGNS THE CURRENT IMAGE, I, RELATIVE TO PREVIOUS IMAGE I-1, AND SENDS THE ALIGNED CURRENT IMAGE TO ALIGNED CURRENT IMAGE SEPARATOR 2230
2305
ALIGNED CURRENT IMAGE SEPARATOR 2230 SEPARATES THE IMAGE INTO SUB-IMAGES, AND SENDS THEM TO SUB-IMAGE ANALYZER 2240
2310
SUB-IMAGE ANALYZER 2240 ANALYZES THE SUB-IMAGES AND MARKS EACH SUB-IMAGE AS “TO BE USED IN THE BACKGROUND IMAGE” OR “TO BE DISREGARDED”
THE SUB-IMAGES AND THE ASSOCIATED MARKS ARE SENT TO BACKGROUND IMAGE GENERATOR 2250
2315
TO STEP 2320 OF FIG. 23B

FIG. 23B


FROM STEP 2315 OF FIG 23A
BACKGROUND IMAGE GENERATOR 2250 PLACES THE SUB-IMAGES WITH THE "USE" MARK IN BACKGROUND IMAGE MEMORY 2270 WHILE OVERRIDING THE CORRESPONDING AREA
2320
BACKGROUND IMAGE ANALYZER 2260 GETS THE BACKGROUND IMAGE FROM BACKGROUND IMAGE MEMORY 2270 AND CHECKS IF THE BACKGROUND IMAGE IS ADEQUATE. IF IT IS, A FINAL IMAGE GENERATION ANNOUNCEMENT IS SENT TO DIGITAL IMAGING DEVICE 10 AND THE BACKGROUND IMAGE FROM BACKGROUND IMAGE MEMORY 2270 IS SENT TO FINAL IMAGE MEMORY 80
2325

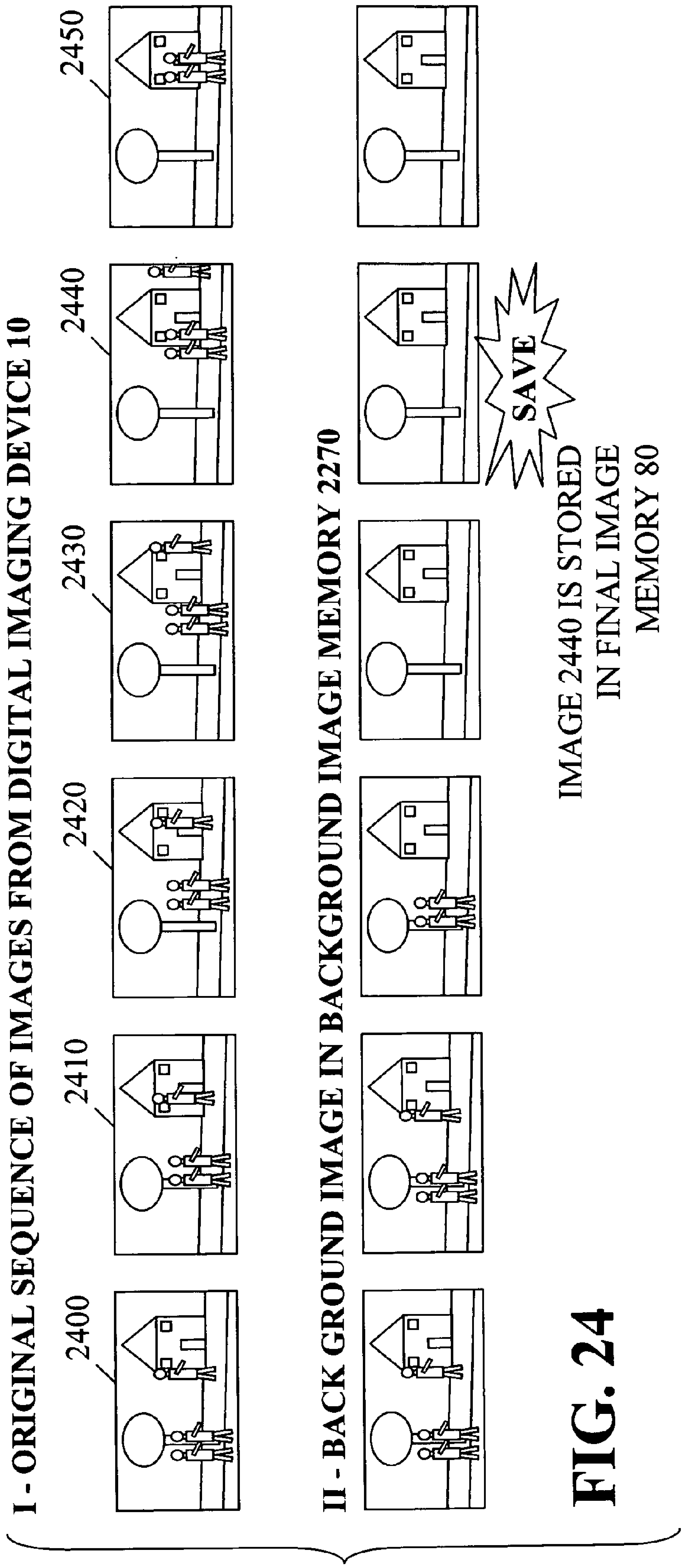

I - ORIGINAL SEQUENCE OF IMAGES FROM DIGITAL IMAGING DEVICE 10
2400
2410
2420
2430
2440
2450
II - BACK GROUND IMAGE IN BACKGROUND IMAGE MEMORY 2270
SAVE
IMAGE 2440 IS STORED
IN FINAL IMAGE
MEMORY 80

FIG. 24

FIG. 25

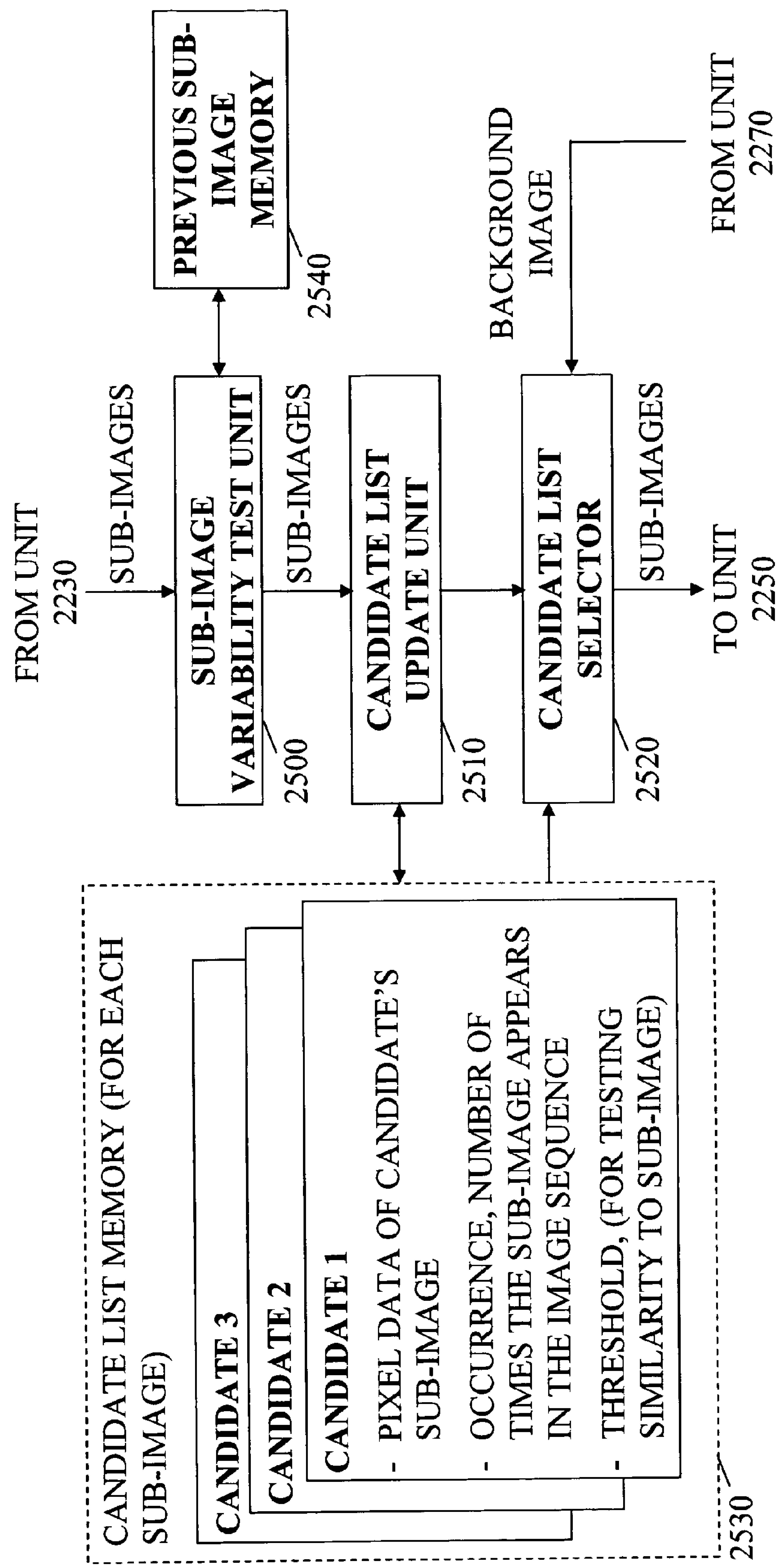

FROM UNIT 2230
SUB-IMAGES
SUB-IMAGE VARIABILITY TEST UNIT
2500
PREVIOUS SUB-IMAGE MEMORY
2540
SUB-IMAGES
CANDIDATE LIST UPDATE UNIT
2510
CANDIDATE LIST SELECTOR
2520
BACKGROUND IMAGE
FROM UNIT 2270
SUB-IMAGES
TO UNIT 2250
CANDIDATE LIST MEMORY (FOR EACH SUB-IMAGE)
CANDIDATE 3
CANDIDATE 2
CANDIDATE 1
- PIXEL DATA OF CANDIDATE'S SUB-IMAGE
- OCCURRENCE, NUMBER OF TIMES THE SUB-IMAGE APPEARS IN THE IMAGE SEQUENCE
- THRESHOLD, (FOR TESTING SIMILARITY TO SUB-IMAGE)
2530

FIG. 26

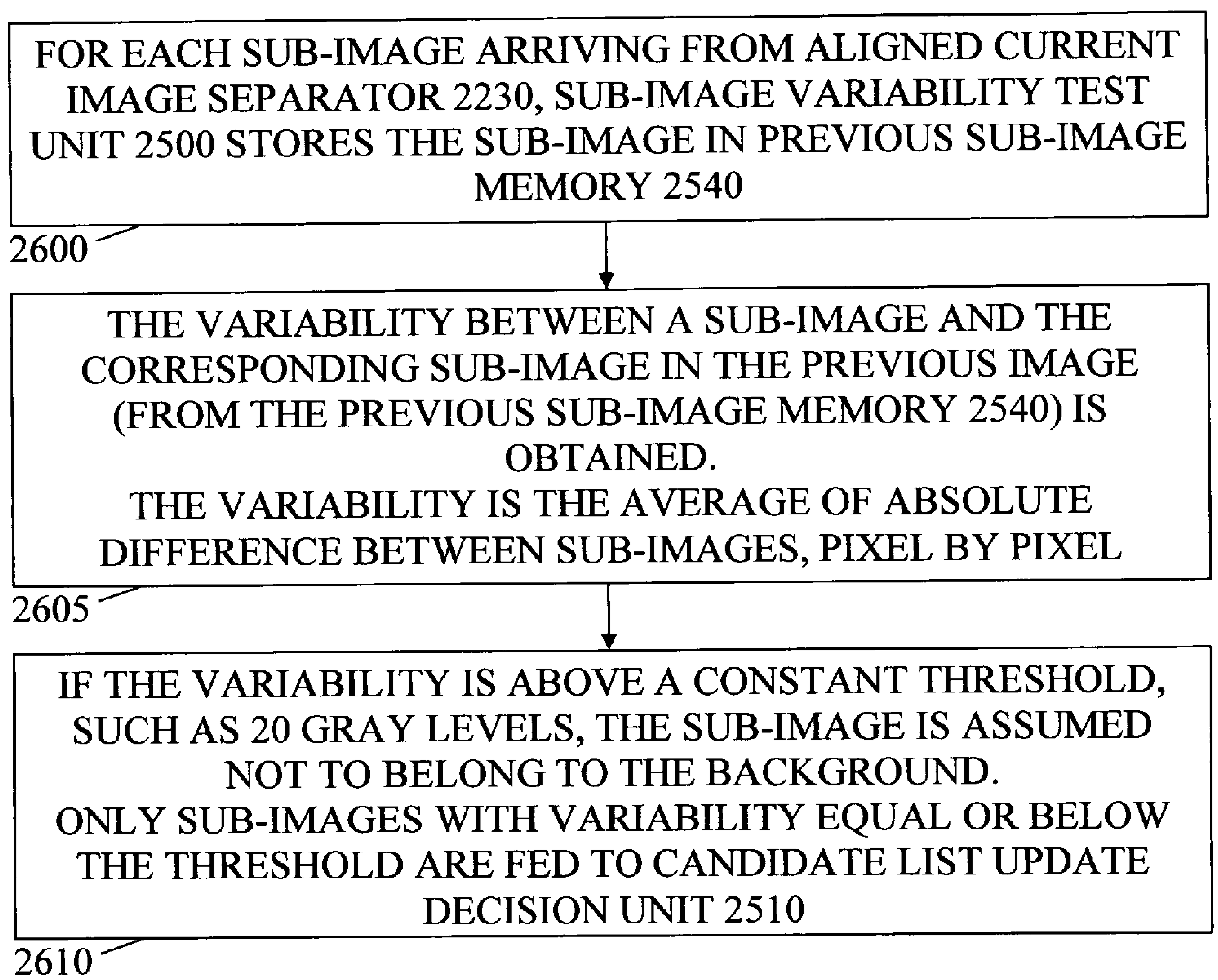

FOR EACH SUB-IMAGE ARRIVING FROM ALIGNED CURRENT IMAGE SEPARATOR 2230, SUB-IMAGE VARIABILITY TEST UNIT 2500 STORES THE SUB-IMAGE IN PREVIOUS SUB-IMAGE MEMORY 2540
2600
THE VARIABILITY BETWEEN A SUB-IMAGE AND THE CORRESPONDING SUB-IMAGE IN THE PREVIOUS IMAGE (FROM THE PREVIOUS SUB-IMAGE MEMORY 2540) IS OBTAINED.
THE VARIABILITY IS THE AVERAGE OF ABSOLUTE DIFFERENCE BETWEEN SUB-IMAGES, PIXEL BY PIXEL
2605
IF THE VARIABILITY IS ABOVE A CONSTANT THRESHOLD, SUCH AS 20 GRAY LEVELS, THE SUB-IMAGE IS ASSUMED NOT TO BELONG TO THE BACKGROUND.
ONLY SUB-IMAGES WITH VARIABILITY EQUAL OR BELOW THE THRESHOLD ARE FED TO CANDIDATE LIST UPDATE DECISION UNIT 2510
2610

FIG. 27

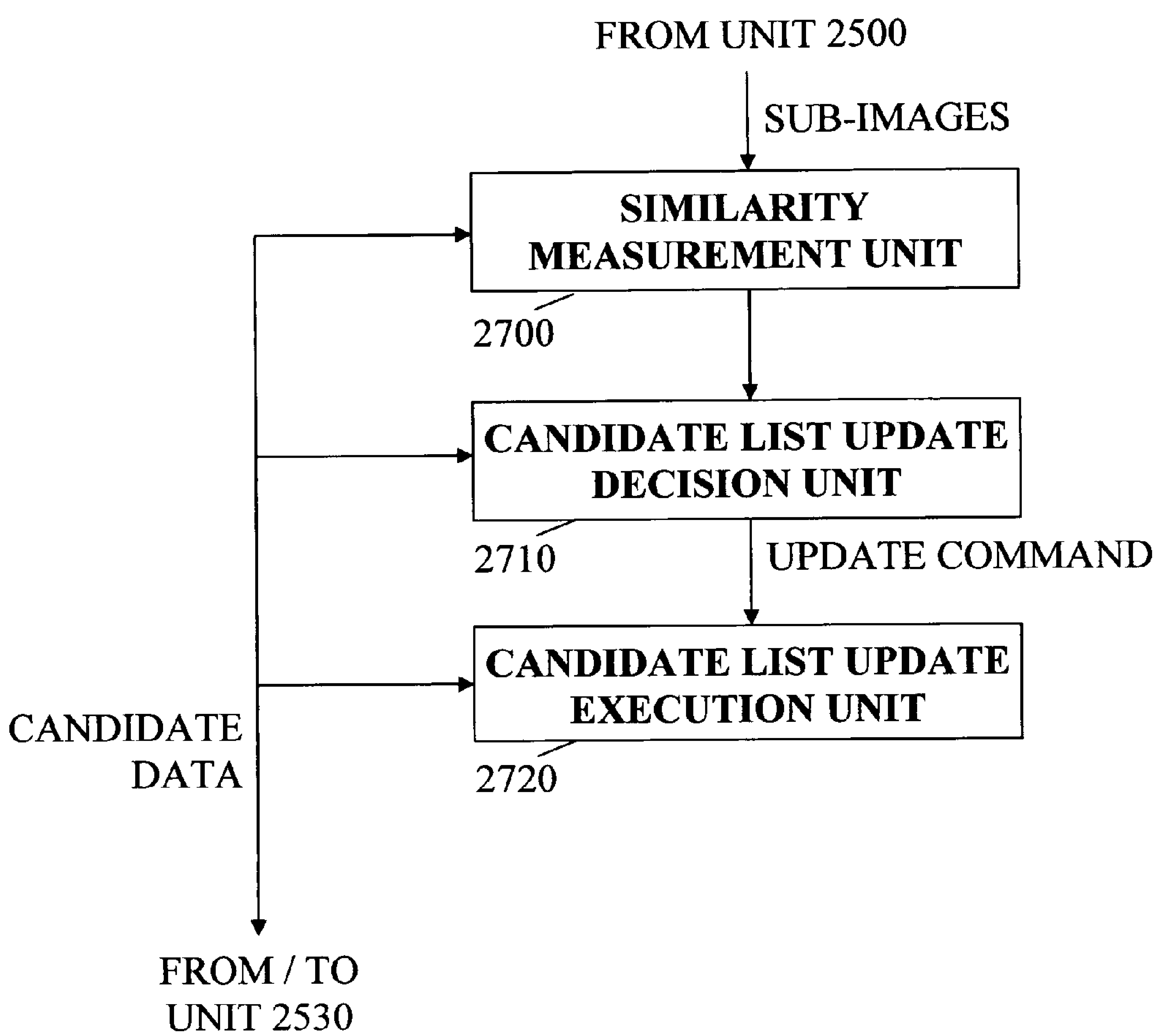

FROM UNIT 2500
SUB-IMAGES
SIMILARITY MEASUREMENT UNIT
2700
CANDIDATE LIST UPDATE DECISION UNIT
2710
UPDATE COMMAND
CANDIDATE LIST UPDATE EXECUTION UNIT
2720
CANDIDATE DATA
FROM / TO UNIT 2530

FIG. 28

SIMILARITY MEASUREMENT UNIT 2700 MEASURES THE DIFFERENCE BETWEEN THE SUB-IMAGE AND ALL THE CORRESPONDING CANDIDATES IN THE CANDIDATE LIST 2530. THE DIFFERENCE IS THE AVERAGE OF ABSOLUTE PIXEL DIFFERENCE BETWEEN SUB-IMAGE AND CANDIDATE IMAGE

2800

CANDIDATE LIST UPDATE DECISION UNIT 2710 COMPARES THE DIFFERENCE FROM EACH CANDIDATE IN CANDIDATE LIST 2530 TO THE CANDIDATE'S THRESHOLD. IF IT IS BELOW THE THRESHOLD THE SUB-IMAGE IS CONSIDERED TO MATCH THE CANDIDATE

2805

IF DIFFERENCE IS ABOVE OR EQUAL THRESHOLD FOR ALL CANDIDATES (NO MATCH WAS FOUND), A REPLACEMENT UPDATE COMMAND IS SENT TO CANDIDATE LIST UPDATE EXECUTION UNIT 2720. ELSE, UPDATE COMMAND IS SENT WITH AN ASSOCIATION TO THE CANDIDATE WITH THE SMALLEST DIFFERENCE TO THE SUB-IMAGE

2810

CANDIDATE LIST UPDATE EXECUTION UNIT 2720 CARRIES OUT:

FOR REPLACEMENT COMMAND:

- REMOVING THE CANDIDATE WITH THE LOWEST OCCURRENCE THAT IS NOT USED IN THE BACKGROUND IMAGE (IF THERE ARE 3 OCCUPIED CANDIDATES)
- INITIALIZING OCCURRENCE AS 1.

FOR UPDATE COMMAND:

- REPLACING ASSOCIATED CANDIDATE IMAGE WITH THE SUB-IMAGE.
- INCREASING OCCURRENCE BY 1.
- UPDATING CANDIDATE THRESHOLD AS A CONSTANT (E.G. 2) MULTIPLIED BY THE AVERAGE OF PREVIOUSLY ASSOCIATED DIFFERENCES (TO MATCHED SUB-IMAGES).

2815

FIG. 29

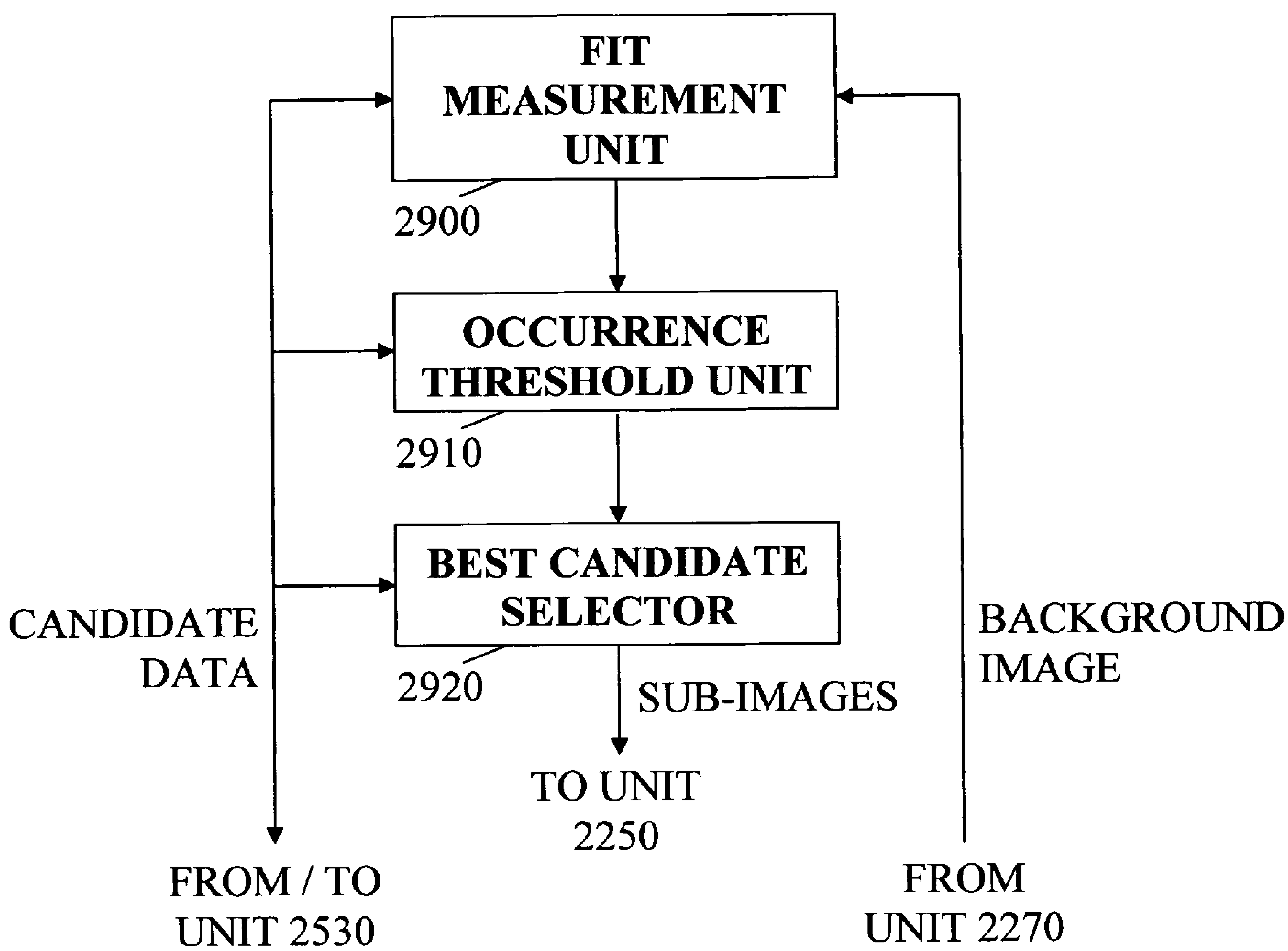

FIT MEASUREMENT UNIT
2900
OCCURRENCE THRESHOLD UNIT
2910
BEST CANDIDATE SELECTOR
2920
CANDIDATE DATA
BACKGROUND IMAGE
SUB-IMAGES
TO UNIT 2250
FROM / TO UNIT 2530
FROM UNIT 2270

FIG. 30

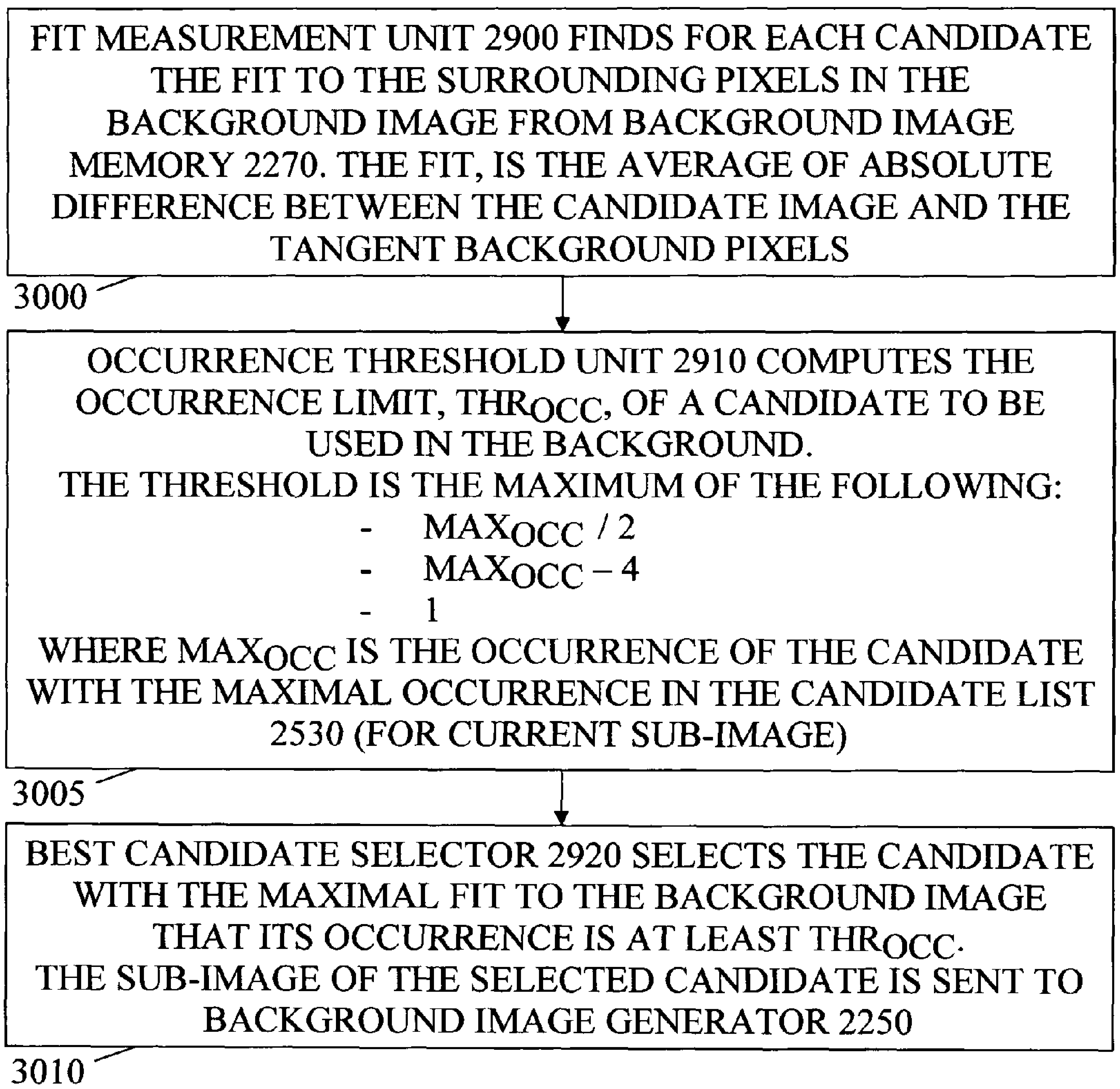

FIT MEASUREMENT UNIT 2900 FINDS FOR EACH CANDIDATE THE FIT TO THE SURROUNDING PIXELS IN THE BACKGROUND IMAGE FROM BACKGROUND IMAGE MEMORY 2270. THE FIT, IS THE AVERAGE OF ABSOLUTE DIFFERENCE BETWEEN THE CANDIDATE IMAGE AND THE TANGENT BACKGROUND PIXELS
3000
OCCURRENCE THRESHOLD UNIT 2910 COMPUTES THE OCCURRENCE LIMIT, THR_{OCC}, OF A CANDIDATE TO BE USED IN THE BACKGROUND.
THE THRESHOLD IS THE MAXIMUM OF THE FOLLOWING:
- $MAX_{OCC} / 2$
- $MAX_{OCC} - 4$
- 1
WHERE MAX_{OCC} IS THE OCCURRENCE OF THE CANDIDATE WITH THE MAXIMAL OCCURRENCE IN THE CANDIDATE LIST 2530 (FOR CURRENT SUB-IMAGE)
3005
BEST CANDIDATE SELECTOR 2920 SELECTS THE CANDIDATE WITH THE MAXIMAL FIT TO THE BACKGROUND IMAGE THAT ITS OCCURRENCE IS AT LEAST THR_{OCC}.
THE SUB-IMAGE OF THE SELECTED CANDIDATE IS SENT TO BACKGROUND IMAGE GENERATOR 2250
3010

FIG. 31

IF THE OCCURRENCE OF ALL SELECTED CANDIDATES IS ABOVE A CONSTANT THRESHOLD (E.G. 10 OCCURRENCES):

- SEND THE BACKGROUND IMAGE FROM BACKGROUND IMAGE MEMORY 2270 TO FINAL IMAGE MEMORY 80
- SEND IMAGE IN SEND FINAL IMAGE GENERATION ANNOUNCEMENT TO 10
- EXIT

3100

IF THE MAXIMAL PROCESS TIME FROM SHUTTER HAS PASSED (DEFINED IN OPTION CONFIGURATION DATABASE 70):

- SEND THE BACKGROUND IMAGE FROM BACKGROUND IMAGE MEMORY 2270 TO FINAL IMAGE MEMORY 80
- SEND FINAL IMAGE GENERATION ANNOUNCEMENT TO DIGITAL IMAGING DEVICE 10

3110

FIG. 32

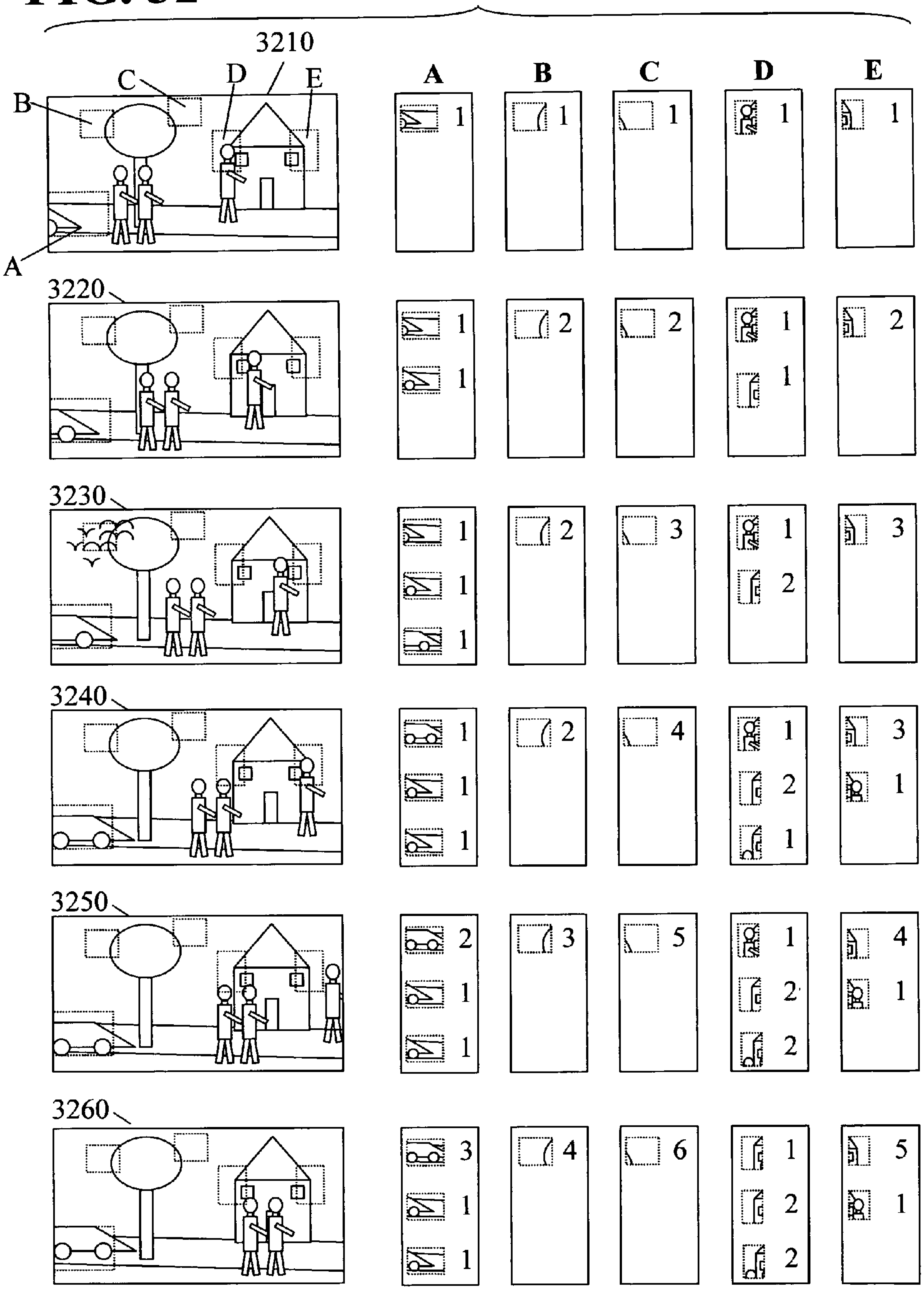


FIG. 33

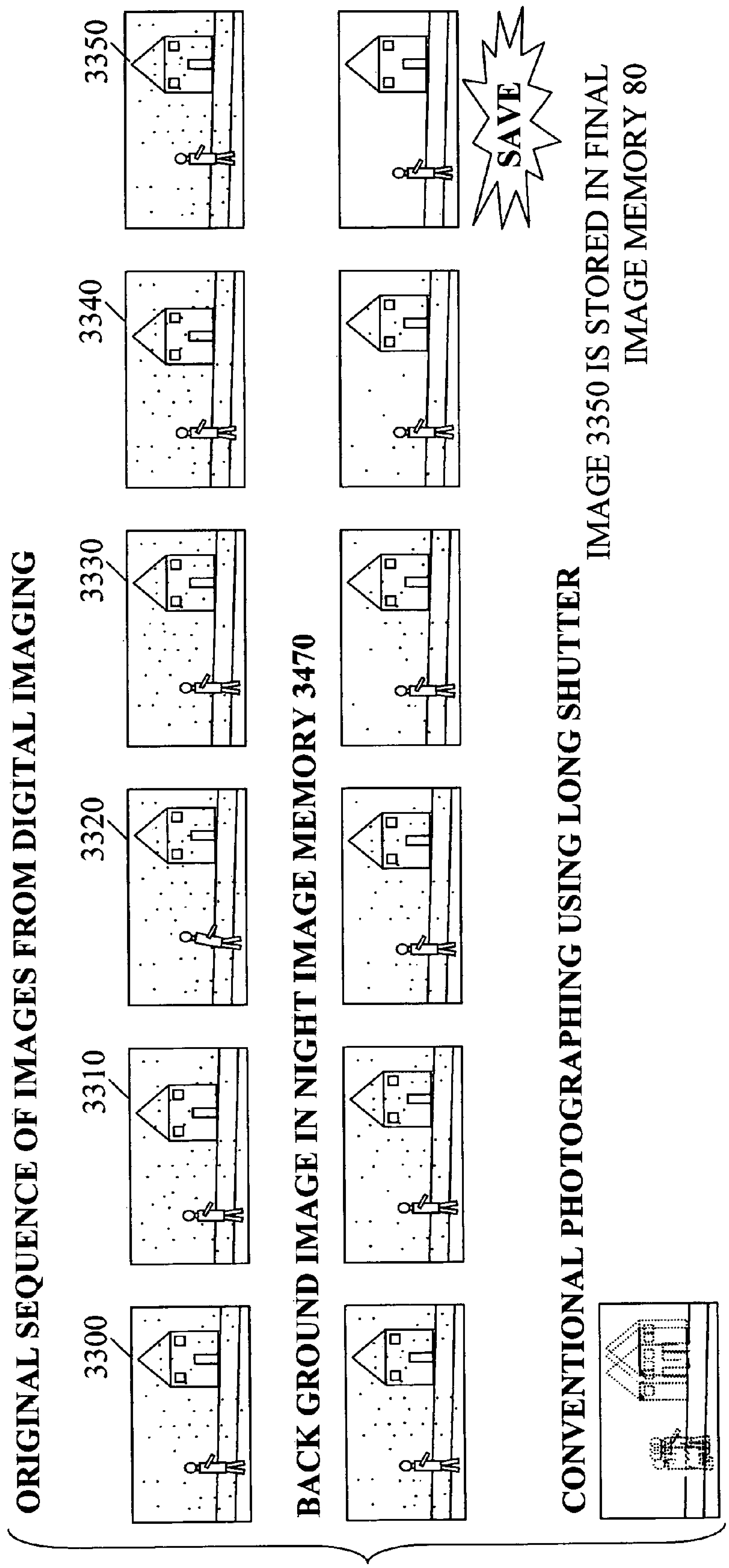

ORIGINAL SEQUENCE OF IMAGES FROM DIGITAL IMAGING
3300
3310
3320
3330
3340
3350
BACK GROUND IMAGE IN NIGHT IMAGE MEMORY 3470
SAVE
IMAGE 3350 IS STORED IN FINAL IMAGE MEMORY 80
CONVENTIONAL PHOTOGRAPHING USING LONG SHUTTER

FIG. 34

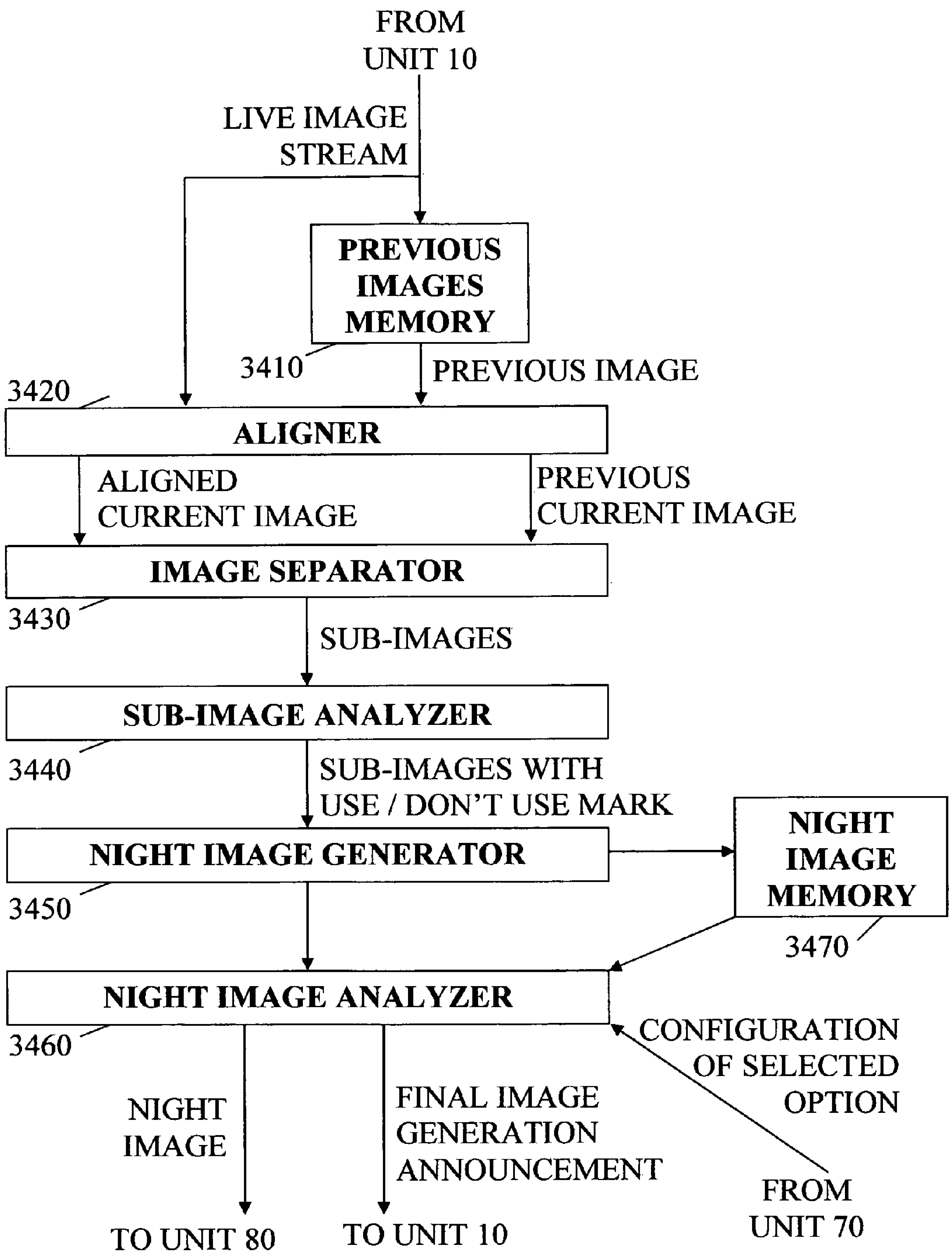

FROM
UNIT 10
LIVE IMAGE
STREAM
PREVIOUS
IMAGES
MEMORY
3410
PREVIOUS IMAGE
3420
ALIGNER
ALIGNED
CURRENT IMAGE
PREVIOUS
CURRENT IMAGE
IMAGE SEPARATOR
3430
SUB-IMAGES
SUB-IMAGE ANALYZER
3440
SUB-IMAGES WITH
USE / DON'T USE MARK
NIGHT IMAGE GENERATOR
3450
NIGHT
IMAGE
MEMORY
3470
NIGHT IMAGE ANALYZER
3460
CONFIGURATION
OF SELECTED
OPTION
NIGHT
IMAGE
FINAL IMAGE
GENERATION
ANNOUNCEMENT
FROM
UNIT 70
TO UNIT 80
TO UNIT 10

FIG. 35A

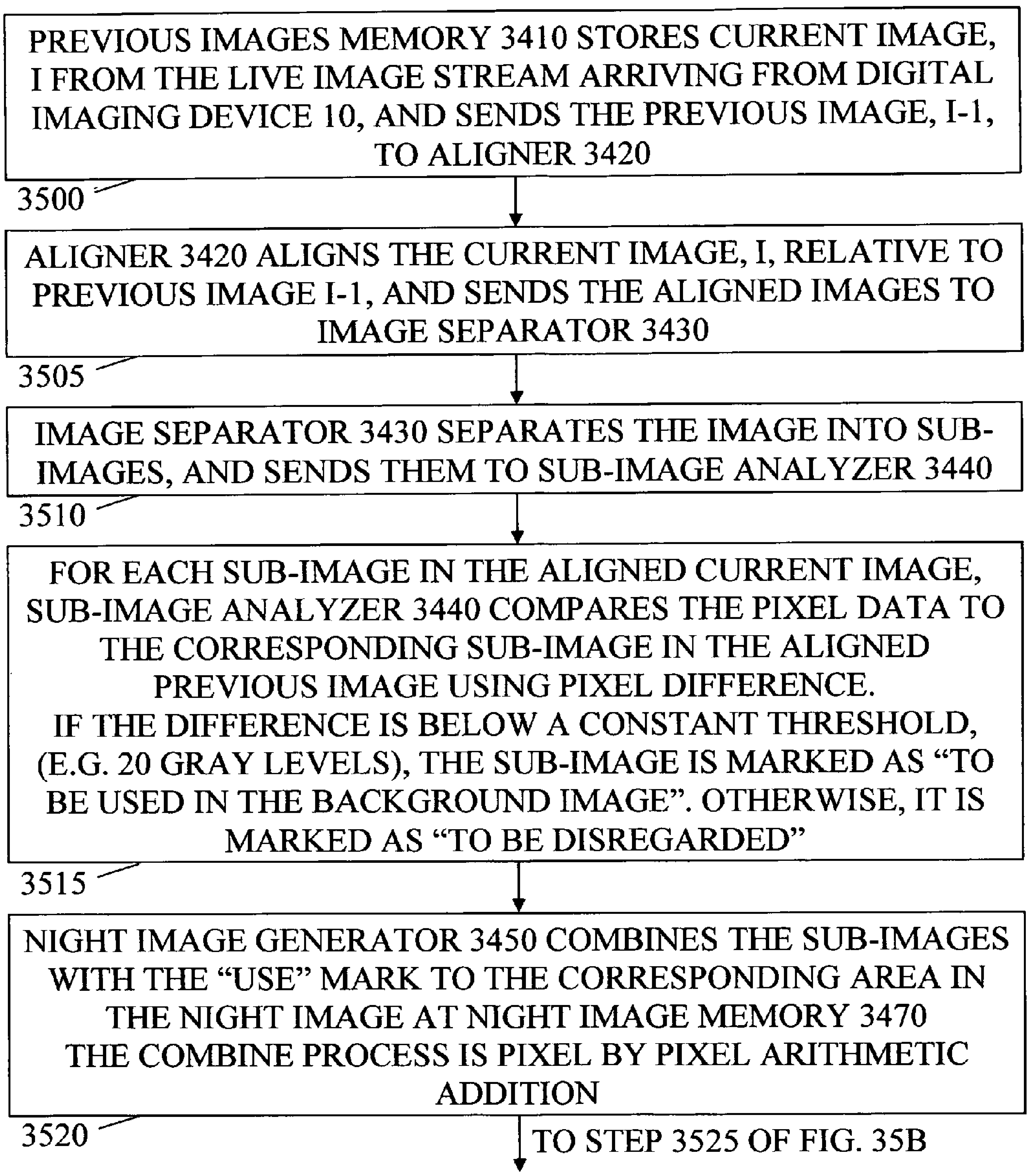

PREVIOUS IMAGES MEMORY 3410 STORES CURRENT IMAGE, I FROM THE LIVE IMAGE STREAM ARRIVING FROM DIGITAL IMAGING DEVICE 10, AND SENDS THE PREVIOUS IMAGE, I-1, TO ALIGNER 3420
3500
ALIGNER 3420 ALIGNS THE CURRENT IMAGE, I, RELATIVE TO PREVIOUS IMAGE I-1, AND SENDS THE ALIGNED IMAGES TO IMAGE SEPARATOR 3430
3505
IMAGE SEPARATOR 3430 SEPARATES THE IMAGE INTO SUB-IMAGES, AND SENDS THEM TO SUB-IMAGE ANALYZER 3440
3510
FOR EACH SUB-IMAGE IN THE ALIGNED CURRENT IMAGE, SUB-IMAGE ANALYZER 3440 COMPARES THE PIXEL DATA TO THE CORRESPONDING SUB-IMAGE IN THE ALIGNED PREVIOUS IMAGE USING PIXEL DIFFERENCE.
IF THE DIFFERENCE IS BELOW A CONSTANT THRESHOLD, (E.G. 20 GRAY LEVELS), THE SUB-IMAGE IS MARKED AS “TO BE USED IN THE BACKGROUND IMAGE”. OTHERWISE, IT IS MARKED AS “TO BE DISREGARDED”
3515
NIGHT IMAGE GENERATOR 3450 COMBINES THE SUB-IMAGES WITH THE “USE” MARK TO THE CORRESPONDING AREA IN THE NIGHT IMAGE AT NIGHT IMAGE MEMORY 3470
THE COMBINE PROCESS IS PIXEL BY PIXEL ARITHMETIC ADDITION
3520
TO STEP 3525 OF FIG. 35B

FIG. 35B

FROM STEP 3520 OF FIG 35A

NIGHT IMAGE GENERATOR 3450 COUNTS HOW MANY ADDITION PROCESSES WHERE CARRIED OUT FOR EACH SUB-IMAGE LOCATION. THE COUNT IS STORED IN THE NIGHT IMAGE MEMORY 3470

3525

NIGHT IMAGE ANALYZER 3460 CREATES NORMALIZED NIGHT IMAGE BY DIVIDING EACH PIXEL IN THE NIGHT IMAGE AT THE NIGHT IMAGE MEMORY BY THE COUNT OF THE ADDING PROCESS OF CORRESPONDING LOCATION

3530

NIGHT IMAGE ANALYZER 3460 COMPUTES THE NOISE, N_{IMG} OF THE IMAGE. THE NOISE IS COMPUTED AS THE STANDARD DEVIATION OF THE DIFFERENCE BETWEEN THE CURRENT IMAGE AND THE NORMALIZED NIGHT IMAGE, ONLY FOR THE "USE" SUB-IMAGES. THE SCENE IS ADEQUATE IF:

- NUMBER OF IMAGES FROM SHUTTER TIME UNTIL CURRENT TIME IS LARGER THAN $(N_{IMG} / N_{CONFIGURATION})^2$ ($N_{CONFIGURATION}$ IS DEFINED IN OPTION CONFIGURATION DATABASE 70)
- TIME FROM SHUTTER IS LARGER THAN MAXIMAL PROCESS TIME DEFINED IN OPTION CONFIGURATION DATABASE 70)

3535

IF THE SCENE IS ADEQUATE NIGHT IMAGE ANALYZER 3460 SENDS THE NORMALIZED NIGHT IMAGE TO FINAL IMAGE MEMORY 80 AND SENDS FINAL IMAGE GENERATION ANNOUNCEMENT TO DIGITAL IMAGING DEVICE 10

3540

FIG. 36

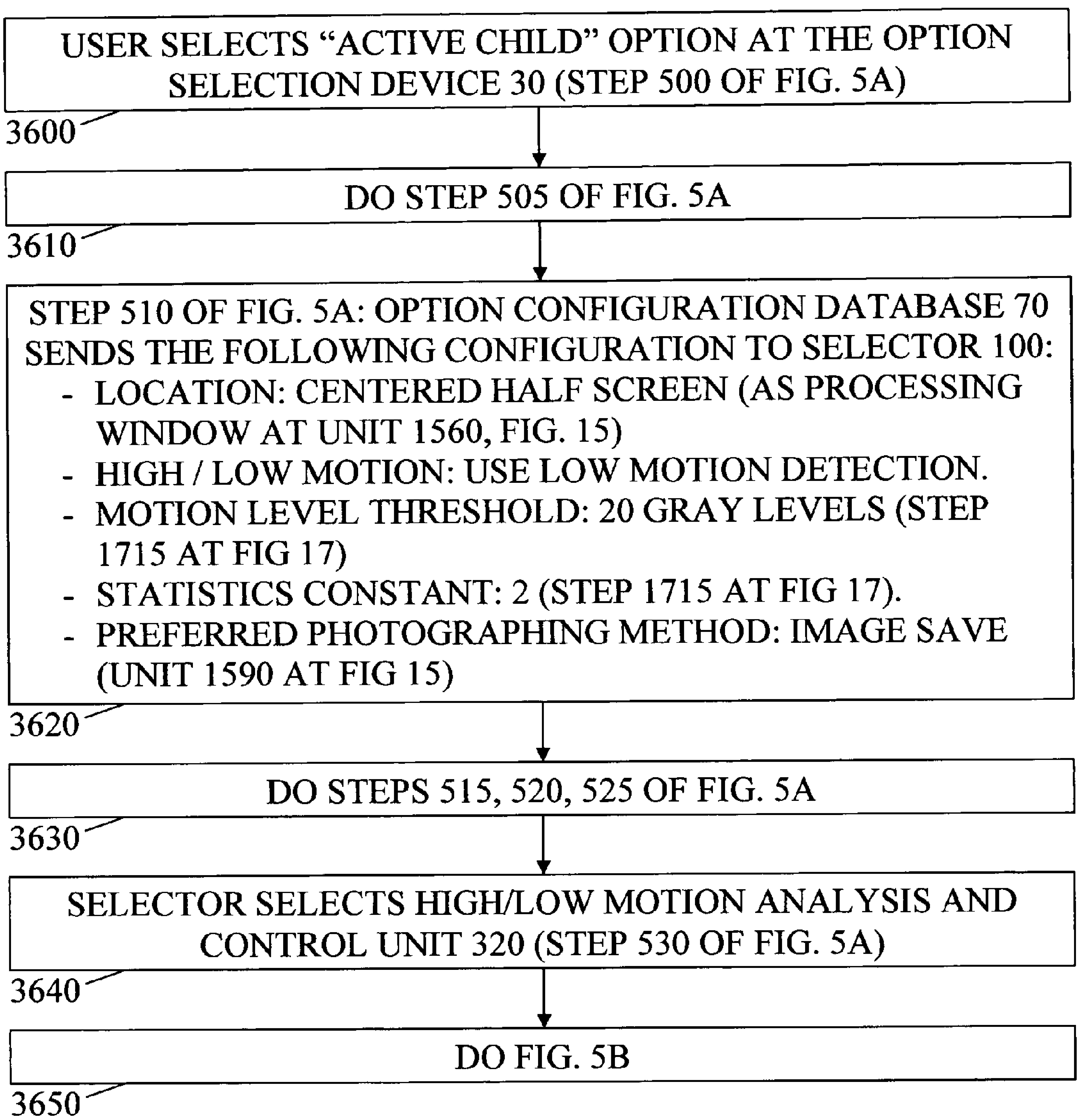

USER SELECTS “ACTIVE CHILD” OPTION AT THE OPTION SELECTION DEVICE 30 (STEP 500 OF FIG. 5A)
3600
DO STEP 505 OF FIG. 5A
3610
STEP 510 OF FIG. 5A: OPTION CONFIGURATION DATABASE 70 SENDS THE FOLLOWING CONFIGURATION TO SELECTOR 100:
- LOCATION: CENTERED HALF SCREEN (AS PROCESSING WINDOW AT UNIT 1560, FIG. 15)
- HIGH / LOW MOTION: USE LOW MOTION DETECTION.
- MOTION LEVEL THRESHOLD: 20 GRAY LEVELS (STEP 1715 AT FIG 17)
- STATISTICS CONSTANT: 2 (STEP 1715 AT FIG 17).
- PREFERRED PHOTOGRAPHING METHOD: IMAGE SAVE (UNIT 1590 AT FIG 15)
3620
DO STEPS 515, 520, 525 OF FIG. 5A
3630
SELECTOR SELECTS HIGH/LOW MOTION ANALYSIS AND CONTROL UNIT 320 (STEP 530 OF FIG. 5A)
3640
DO FIG. 5B
3650

FIG. 37

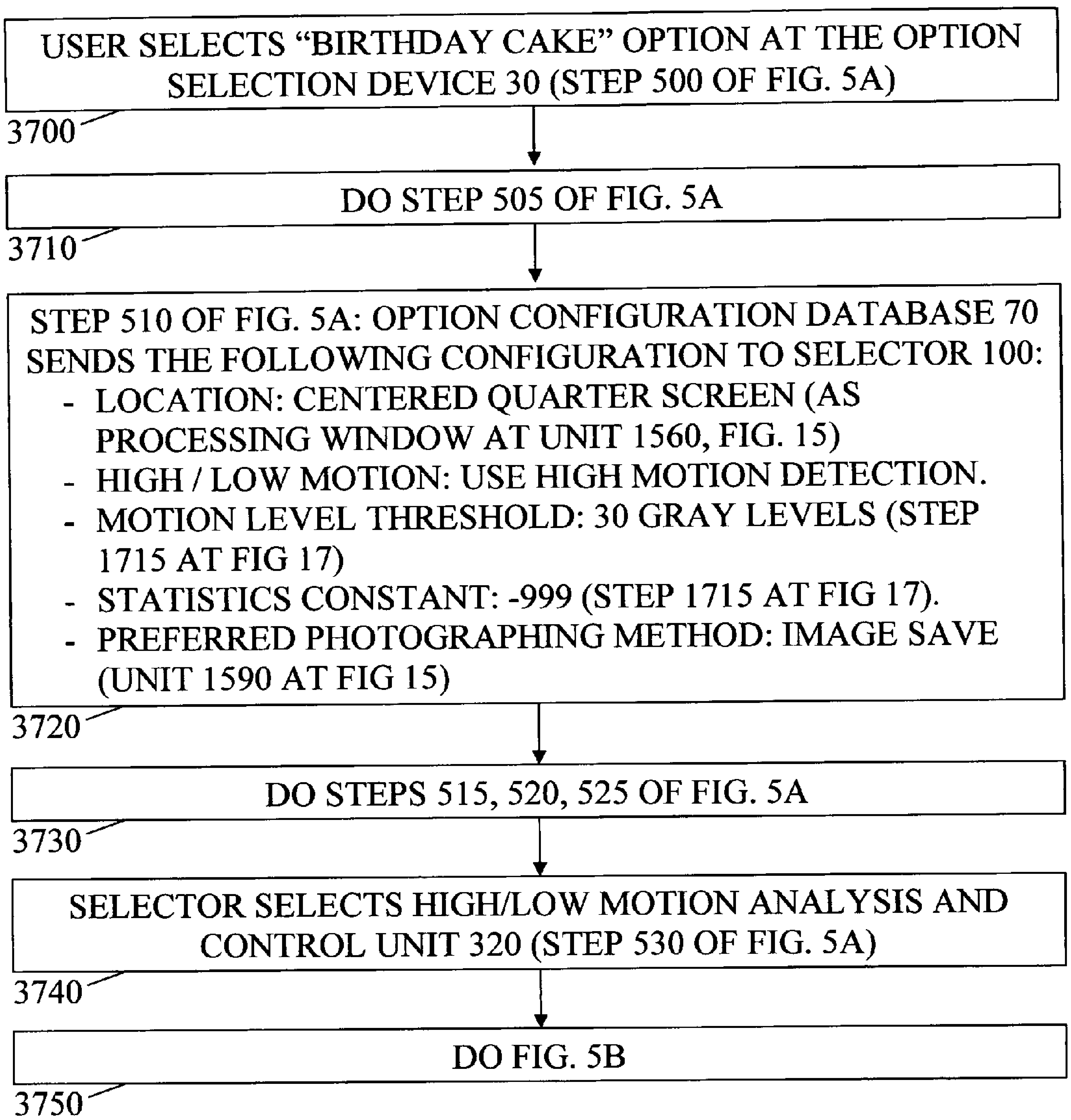
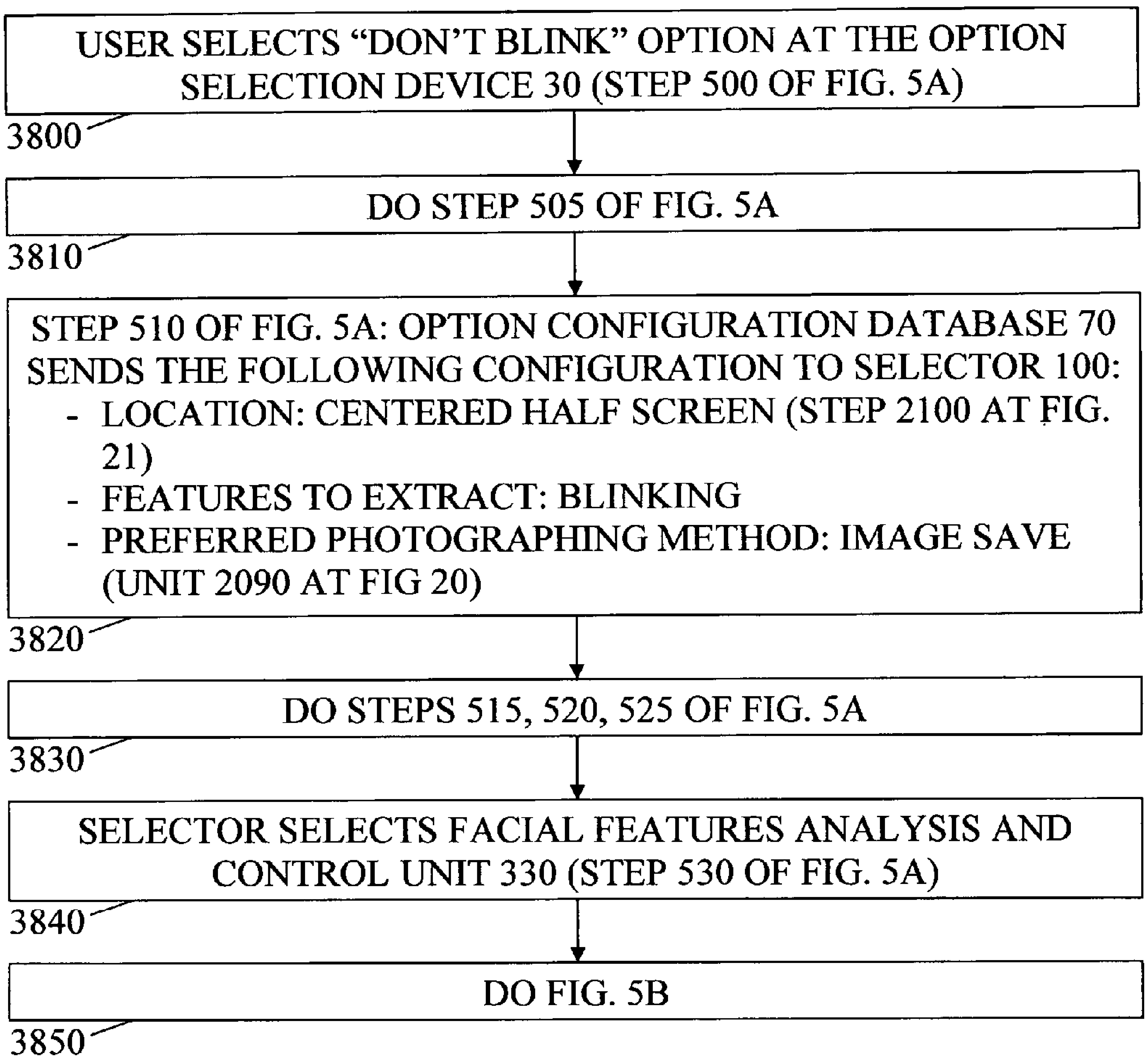

USER SELECTS "BIRTHDAY CAKE" OPTION AT THE OPTION SELECTION DEVICE 30 (STEP 500 OF FIG. 5A)
3700
DO STEP 505 OF FIG. 5A
3710
STEP 510 OF FIG. 5A: OPTION CONFIGURATION DATABASE 70 SENDS THE FOLLOWING CONFIGURATION TO SELECTOR 100:
- LOCATION: CENTERED QUARTER SCREEN (AS PROCESSING WINDOW AT UNIT 1560, FIG. 15)
- HIGH / LOW MOTION: USE HIGH MOTION DETECTION.
- MOTION LEVEL THRESHOLD: 30 GRAY LEVELS (STEP 1715 AT FIG 17)
- STATISTICS CONSTANT: -999 (STEP 1715 AT FIG 17).
- PREFERRED PHOTOGRAPHING METHOD: IMAGE SAVE (UNIT 1590 AT FIG 15)
3720
DO STEPS 515, 520, 525 OF FIG. 5A
3730
SELECTOR SELECTS HIGH/LOW MOTION ANALYSIS AND CONTROL UNIT 320 (STEP 530 OF FIG. 5A)
3740
DO FIG. 5B
3750

FIG. 38



USER SELECTS "DON'T BLINK" OPTION AT THE OPTION SELECTION DEVICE 30 (STEP 500 OF FIG. 5A)
3800
DO STEP 505 OF FIG. 5A
3810
STEP 510 OF FIG. 5A: OPTION CONFIGURATION DATABASE 70 SENDS THE FOLLOWING CONFIGURATION TO SELECTOR 100:
- LOCATION: CENTERED HALF SCREEN (STEP 2100 AT FIG. 21)
- FEATURES TO EXTRACT: BLINKING
- PREFERRED PHOTOGRAPHING METHOD: IMAGE SAVE (UNIT 2090 AT FIG 20)
3820
DO STEPS 515, 520, 525 OF FIG. 5A
3830
SELECTOR SELECTS FACIAL FEATURES ANALYSIS AND CONTROL UNIT 330 (STEP 530 OF FIG. 5A)
3840
DO FIG. 5B
3850

FIG. 39

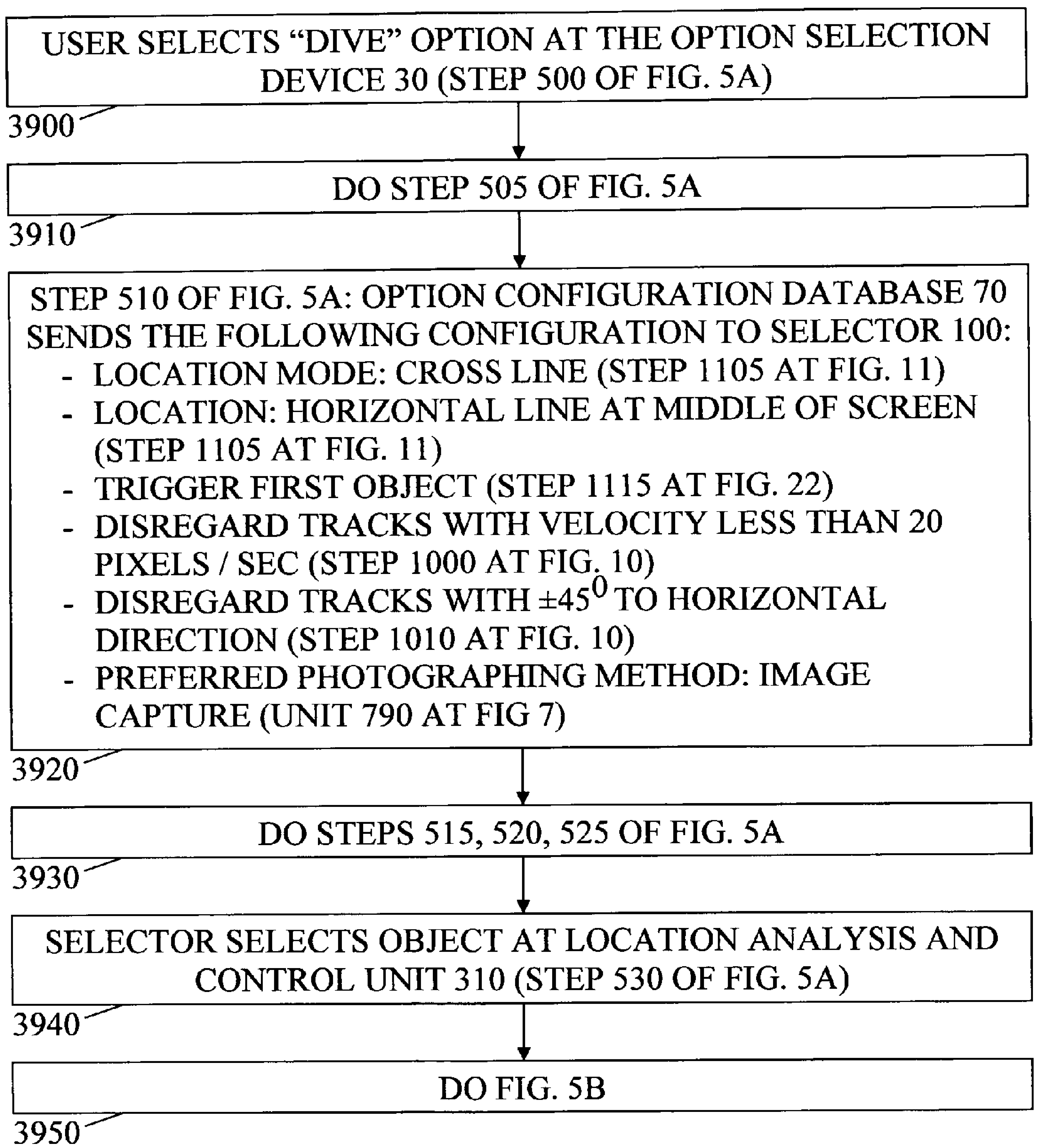

USER SELECTS "DIVE" OPTION AT THE OPTION SELECTION DEVICE 30 (STEP 500 OF FIG. 5A)
3900
DO STEP 505 OF FIG. 5A
3910
STEP 510 OF FIG. 5A: OPTION CONFIGURATION DATABASE 70 SENDS THE FOLLOWING CONFIGURATION TO SELECTOR 100:
- LOCATION MODE: CROSS LINE (STEP 1105 AT FIG. 11)
- LOCATION: HORIZONTAL LINE AT MIDDLE OF SCREEN (STEP 1105 AT FIG. 11)
- TRIGGER FIRST OBJECT (STEP 1115 AT FIG. 22)
- DISREGARD TRACKS WITH VELOCITY LESS THAN 20 PIXELS / SEC (STEP 1000 AT FIG. 10)
- DISREGARD TRACKS WITH ±45^{0} TO HORIZONTAL DIRECTION (STEP 1010 AT FIG. 10)
- PREFERRED PHOTOGRAPHING METHOD: IMAGE CAPTURE (UNIT 790 AT FIG 7)
3920
DO STEPS 515, 520, 525 OF FIG. 5A
3930
SELECTOR SELECTS OBJECT AT LOCATION ANALYSIS AND CONTROL UNIT 310 (STEP 530 OF FIG. 5A)
3940
DO FIG. 5B
3950

FIG. 40

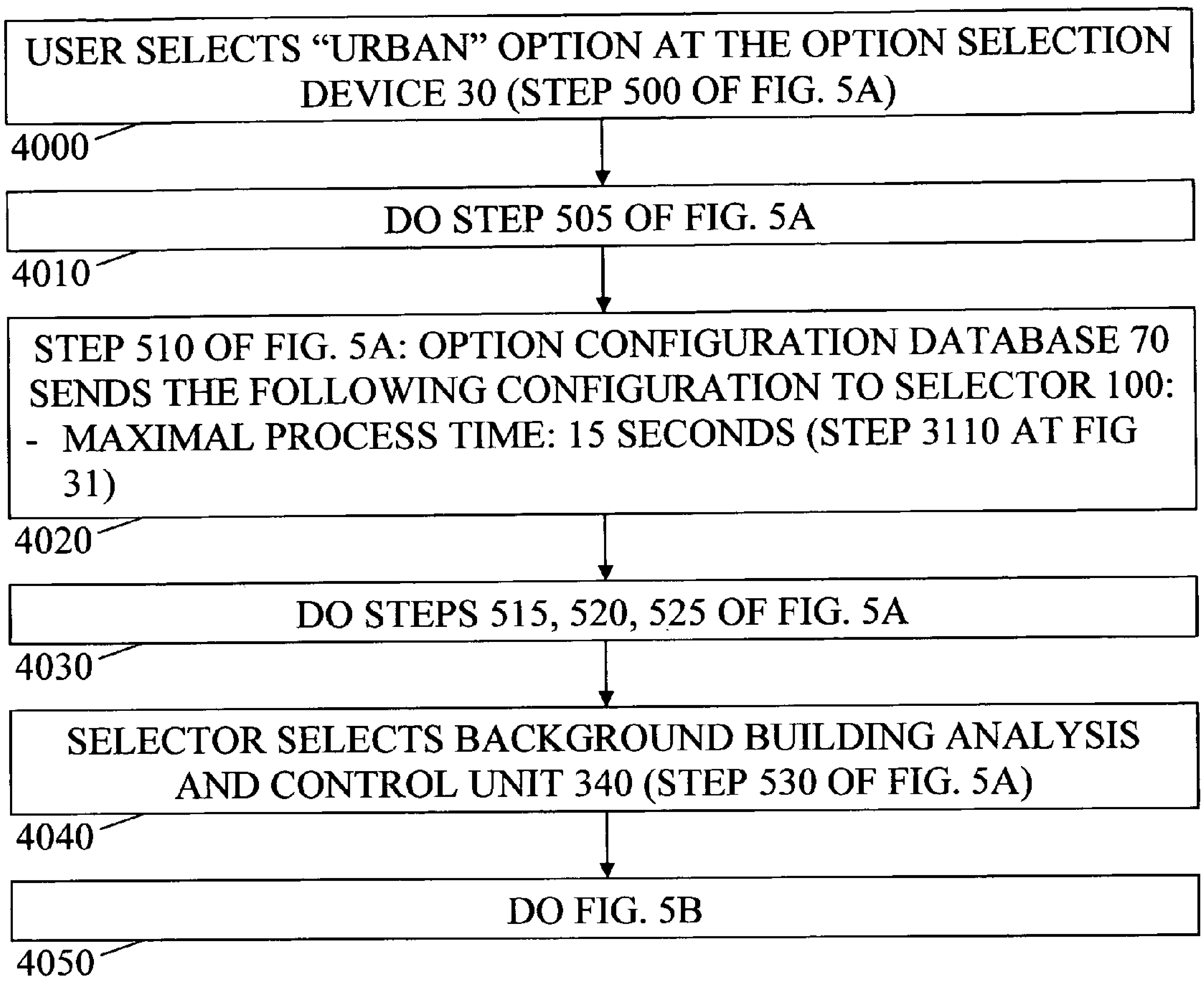

USER SELECTS "URBAN" OPTION AT THE OPTION SELECTION DEVICE 30 (STEP 500 OF FIG. 5A)
4000
DO STEP 505 OF FIG. 5A
4010
STEP 510 OF FIG. 5A: OPTION CONFIGURATION DATABASE 70 SENDS THE FOLLOWING CONFIGURATION TO SELECTOR 100:
- MAXIMAL PROCESS TIME: 15 SECONDS (STEP 3110 AT FIG 31)
4020
DO STEPS 515, 520, 525 OF FIG. 5A
4030
SELECTOR SELECTS BACKGROUND BUILDING ANALYSIS AND CONTROL UNIT 340 (STEP 530 OF FIG. 5A)
4040
DO FIG. 5B
4050

FIG. 41

4100: USER SELECTS "NIGHT" OPTION AT THE OPTION SELECTION DEVICE 30 (STEP 500 OF FIG. 5A)

↓

4110: DO STEP 505 OF FIG. 5A

↓

4120: STEP 510 OF FIG. 5A: OPTION CONFIGURATION DATABASE 70 SENDS THE FOLLOWING CONFIGURATION TO SELECTOR 100:
- MAXIMAL PROCESS TIME: 15 SECONDS (STEP 3535 AT FIG 35)
- REQUESTED NOISE LEVEL ($N_{CONFIGURATION}$): 5 GRAY LEVELS (STEP 3535 AT FIG 35)

↓

4130: DO STEPS 515, 520, 525 OF FIG. 5A

↓

4140: SELECTOR SELECTS NOISE REDUCTION ANALYSIS AND CONTROL UNIT 350 (STEP 530 OF FIG. 5A)

↓

4150: DO FIG. 5B

FIG. 42

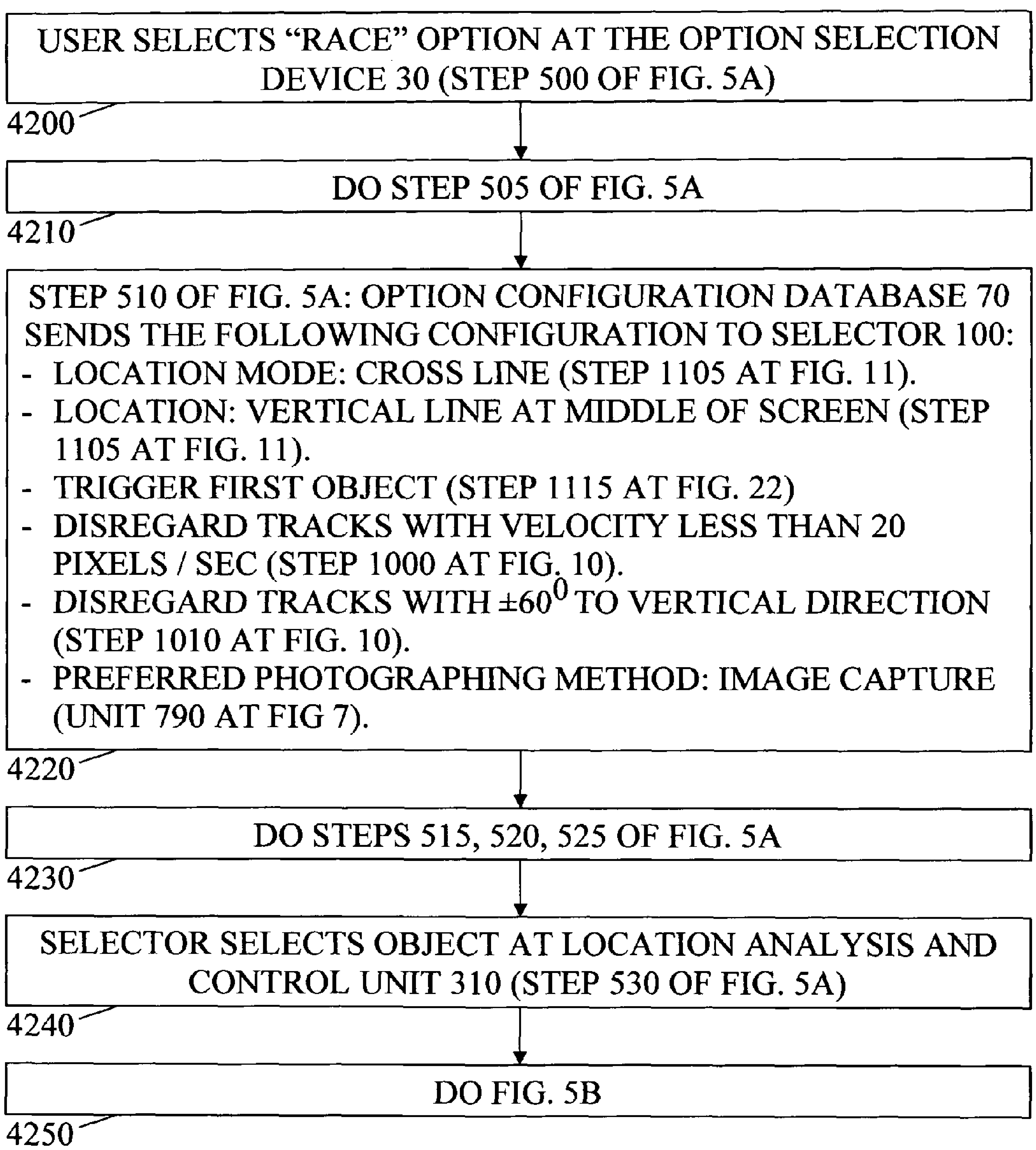

USER SELECTS "RACE" OPTION AT THE OPTION SELECTION DEVICE 30 (STEP 500 OF FIG. 5A)
4200
DO STEP 505 OF FIG. 5A
4210
STEP 510 OF FIG. 5A: OPTION CONFIGURATION DATABASE 70 SENDS THE FOLLOWING CONFIGURATION TO SELECTOR 100:
- LOCATION MODE: CROSS LINE (STEP 1105 AT FIG. 11).
- LOCATION: VERTICAL LINE AT MIDDLE OF SCREEN (STEP 1105 AT FIG. 11).
- TRIGGER FIRST OBJECT (STEP 1115 AT FIG. 22)
- DISREGARD TRACKS WITH VELOCITY LESS THAN 20 PIXELS / SEC (STEP 1000 AT FIG. 10).
- DISREGARD TRACKS WITH ±60^0 TO VERTICAL DIRECTION (STEP 1010 AT FIG. 10).
- PREFERRED PHOTOGRAPHING METHOD: IMAGE CAPTURE (UNIT 790 AT FIG 7).
4220
DO STEPS 515, 520, 525 OF FIG. 5A
4230
SELECTOR SELECTS OBJECT AT LOCATION ANALYSIS AND CONTROL UNIT 310 (STEP 530 OF FIG. 5A)
4240
DO FIG. 5B
4250

FIG. 43

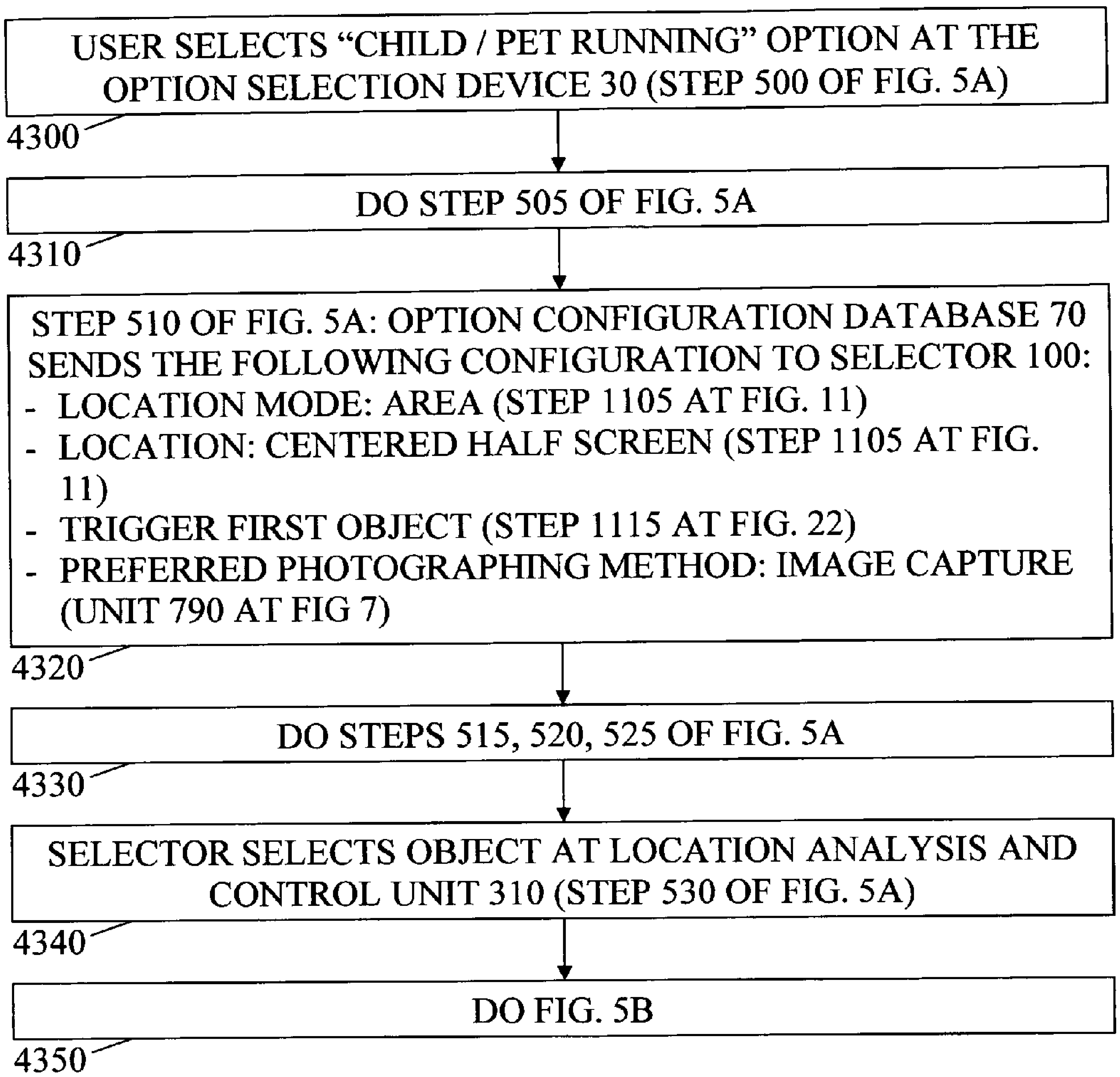

USER SELECTS "CHILD / PET RUNNING" OPTION AT THE OPTION SELECTION DEVICE 30 (STEP 500 OF FIG. 5A)
4300
DO STEP 505 OF FIG. 5A
4310
STEP 510 OF FIG. 5A: OPTION CONFIGURATION DATABASE 70 SENDS THE FOLLOWING CONFIGURATION TO SELECTOR 100:
- LOCATION MODE: AREA (STEP 1105 AT FIG. 11)
- LOCATION: CENTERED HALF SCREEN (STEP 1105 AT FIG. 11)
- TRIGGER FIRST OBJECT (STEP 1115 AT FIG. 22)
- PREFERRED PHOTOGRAPHING METHOD: IMAGE CAPTURE (UNIT 790 AT FIG 7)
4320
DO STEPS 515, 520, 525 OF FIG. 5A
4330
SELECTOR SELECTS OBJECT AT LOCATION ANALYSIS AND CONTROL UNIT 310 (STEP 530 OF FIG. 5A)
4340
DO FIG. 5B
4350

FIG. 44

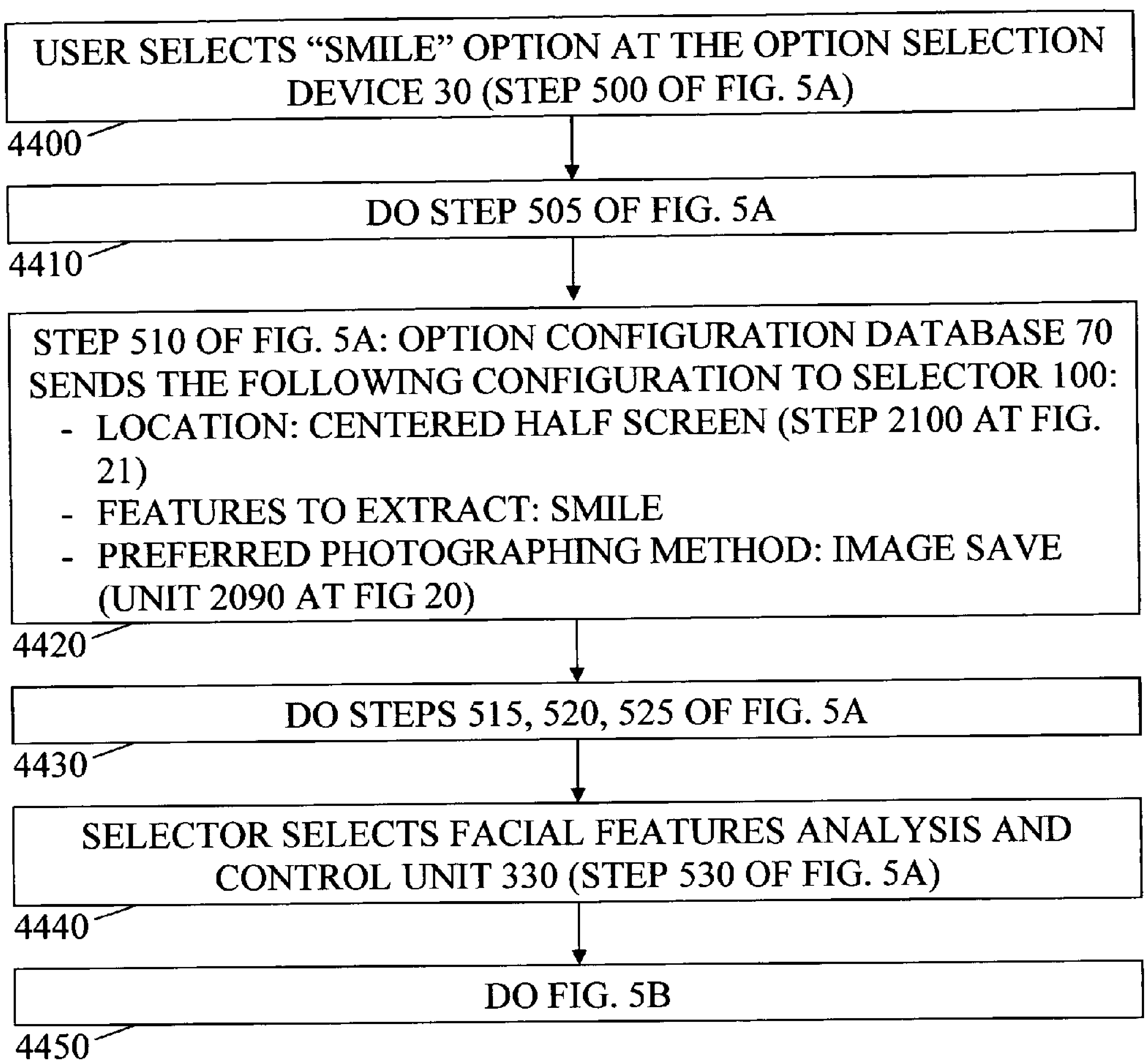

USER SELECTS "SMILE" OPTION AT THE OPTION SELECTION DEVICE 30 (STEP 500 OF FIG. 5A)
4400
DO STEP 505 OF FIG. 5A
4410
STEP 510 OF FIG. 5A: OPTION CONFIGURATION DATABASE 70 SENDS THE FOLLOWING CONFIGURATION TO SELECTOR 100:
- LOCATION: CENTERED HALF SCREEN (STEP 2100 AT FIG. 21)
- FEATURES TO EXTRACT: SMILE
- PREFERRED PHOTOGRAPHING METHOD: IMAGE SAVE (UNIT 2090 AT FIG 20)
4420
DO STEPS 515, 520, 525 OF FIG. 5A
4430
SELECTOR SELECTS FACIAL FEATURES ANALYSIS AND CONTROL UNIT 330 (STEP 530 OF FIG. 5A)
4440
DO FIG. 5B
4450

FIG. 45

USER SELECTS "SURPRISE" OPTION AT THE OPTION SELECTION DEVICE 30 (STEP 500 OF FIG. 5A)

4500

DO STEP 505 OF FIG. 5A

4510

STEP 510 OF FIG. 5A: OPTION CONFIGURATION DATABASE 70 SENDS THE FOLLOWING CONFIGURATION TO SELECTOR 100:

- LOCATION: CENTERED HALF SCREEN (STEP 2100 AT FIG. 21)
- FEATURES TO EXTRACT: SMILE
- PREFERRED PHOTOGRAPHING METHOD: IMAGE SAVE (UNIT 2090 AT FIG 20).

4520

DO STEPS 515, 520, 525 OF FIG. 5A

4530

SELECTOR SELECTS FACIAL FEATURES ANALYSIS AND CONTROL UNIT 330 (STEP 530 OF FIG. 5A)

4540

DO FIG. 5B

4550

FIG. 46A

USER SELECTS "SELF PHOTO" OPTION AT THE OPTION SELECTION DEVICE 30 (STEP 500 OF FIG. 5A)

4600

DO STEP 505 OF FIG. 5A

4605

STEP 510 OF FIG. 5A: OPTION CONFIGURATION DATABASE 70 SENDS THE FOLLOWING CONFIGURATION TO SELECTOR 100:

- LOCATION MODE: AREA (STEP 1105 AT FIG. 11)
- LOCATION: CENTERED HALF SCREEN (STEP 1105 AT FIG. 11)
- TRIGGER FIRST OBJECT (STEP 1115 AT FIG. 22)
- PREFERRED PHOTOGRAPHING METHOD: NOT APPLICABLE

4610

DO STEPS 515, 525 OF FIG. 5A

4615

SELECTOR SELECTS OBJECT AT LOCATION ANALYSIS AND CONTROL UNIT 310 (STEP 530 OF FIG. 5A)
THE UNIT IS ACTIVATED ONLY AS TRIGGER TO ACTIVATE THE NEXT UNIT (HIGH / LOW MOTION ANALYSIS AND CONTROL UNIT 320)

4620

DO STEP 535 OF FIG. 5B

4625

TO STEP 4630 OF FIG. 46B

FIG. 46B

FROM STEP 4625 OF FIG. 46A

WHEN THE OBJECT AT LOCATION ANALYSIS AND CONTROL UNIT 310 DETECTS A MOTION AT THE SPECIFIED LOCATION, THE HIGH / LOW MOTION ANALYSIS AND CONTROL UNIT 320 IS ACTIVATED.

4630

STEP 510 OF FIG. 5A: OPTION CONFIGURATION DATABASE 70 SENDS THE FOLLOWING CONFIGURATION TO SELECTOR 100:

- LOCATION: CENTERED HALF SCREEN (AS PROCESSING WINDOW AT UNIT 1560, FIG. 15)
- HIGH / LOW MOTION: USE LOW MOTION DETECTION.
- MOTION LEVEL THRESHOLD: 20 GRAY LEVELS (STEP 1715 AT FIG 17)
- STATISTICS CONSTANT: 2 (STEP 1715 AT FIG 17)
- PREFERRED PHOTOGRAPHING METHOD: IMAGE SAVE (UNIT 1590 AT FIG 15), O NOT APPLICABLE IF SYSTEM WAITS FOR SMILE

4635

DO STEPS 515, 520, 525 OF FIG. 5A

4640

SELECTOR SELECTS HIGH / LOW MOTION ANALYSIS AND CONTROL UNIT 320 (STEP 530 OF FIG 5A).

4645

DO FIG. 5B. PREFERABLY, UNIT 320 FACIAL FEATURES ANALYSIS AND CONTROL UNIT 330 AND UNIT 330 DETECTS A USER SMILE & TRIGGERS IMAGING ACCORDINGLY OR TIMES OUT. ALTERNATIVELY, UNIT 320 TRIGGERS IMAGING WITHOUT WAITING FOR SMILE

4650

PHOTOGRAPHY-SPECIFIC DIGITAL CAMERA APPARATUS AND METHODS USEFUL IN CONJUNCTION THEREWITH

FIELD OF THE INVENTION

The present invention relates to apparatus and methods for digital photography.

BACKGROUND OF THE INVENTION

A wide variety of digital cameras is currently available. Conventional digital photography options and methods are described e.g. in the manual of the Sony DSC-T7 digital camera.

U.S. Pat. No. 5,774,591 to Black et al describes an apparatus and method for recognizing facial expressions and applications therefor.

The disclosures of all publications mentioned in the specification and of the publications cited therein are hereby incorporated by reference.

SUMMARY OF THE INVENTION

The present invention seeks to provide an application-specific digital camera and methods useful therefor.

There is thus provided, in accordance with a preferred embodiment of the present invention, a digital photography method comprising receiving a definition of a moment at which an anticipated event is to photographed, using a digital imaging device residing in a digital camera to generate a stream of digital images of a location at which tile event is anticipated to occur; and inspecting the stream of digital images, to anticipate the moment in the stream, and to generate a trigger timed and constructed to trigger generation of an image of the location at the moment.

Also provided, in accordance with a preferred embodiment of the present invention, is a digital photography system operative in conjunction with a digital imaging device, the system comprising a moment definition input device defining a moment at which an anticipated event is to photographed, a stream of digital images, generated by the digital imaging device, of a location at which the event is anticipated to occur, and a moment anticipator operative to inspect the stream of digital images, to anticipate the moment in the stream, and to trigger generation of an image of the location at the moment.

Further in accordance with a preferred embodiment of the present invention, the moment anticipator resides on an integrated circuit, the system also comprising a digital imaging device operative to generate the stream and operative in conjunction with the integrated circuit.

Also provided, in accordance with another preferred embodiment of the present invention, is a digital photography method comprising receiving a definition of a moment at which an anticipated event is to photographed, using a digital imaging device residing in a digital camera to generate a stream of digital images of a location at which the event is anticipated to occur; and inspecting the stream of digital images, to detect, in the stream. a digital image which has captured the moment and selectively storing the digital image which has captured the moment. Also provided, in accordance with a preferred embodiment of the present invention, is a digital photography system operative in conjunction with a digital imaging device, the system comprising a moment definition input device defining a moment at which an anticipated event is to photographed, a stream of digital images of a location at which the event is anticipated to occur; and a moment-catching image selector operative to inspect the stream of digital images, to detect. in the stream, a digital image which has captured the moment and to selectively store the digital image which has captured the moment.

Further in accordance with a preferred embodiment of the present invention, the moment-catching image selector resides on an integrated circuit, the system also comprising a digital imaging device operative to generate the stream and operative in conjunction with the integrated circuit.

Further in accordance with a preferred embodiment of the present invention, the definition of the moment comprises a definition of at least one target state of at least one corresponding target object and wherein the moment comprises a moment at which at least one target object is in the at least one target state.

Still further in accordance with a preferred embodiment of the present invention, the target state comprises a target location and wherein the moment comprises a moment at which the target object has reached the target location.

Further in accordance with a preferred embodiment of the present invention, the target object comprises a race participant and the target location comprises a finish line.

Still further in accordance with a preferred embodiment of the present invention the target object comprises an animal or human subject and the target location comprises a user-selected location.

Further in accordance with a preferred embodiment of the present invention, the target object comprises a diver and the target location comprises a location along an expected trajectory of a dive.

Still further in accordance with a preferred embodiment of the present invention, the definition of the moment comprises a definition of a target state of a target object and wherein the moment comprises a moment at which the target object is in the target state.

Further in accordance with a preferred embodiment of the present invention, the target state comprises a target location and wherein the moment comprises a moment at which the target object has reached the target location.

Additionally in accordance with a preferred embodiment of the present invention, the target object comprises a race participant and the target location comprises a finish line.

Still further in accordance with a preferred embodiment of the present invention, the target object comprises an animal or human subject and the target location comprises a user-selected location.

Further in accordance with a preferred embodiment of the present invention, the target object comprises a diver and the target location comprises a location along an expected trajectory of a dive.

Still further in accordance with a preferred embodiment of the present invention, the target state comprises a state at which the target object's level of motion is locally maximal.

Additionally in accordance with a preferred embodiment of the present invention, the target state comprises a state at which the target object's level of motion is locally minimal.

Still further in accordance with a preferred embodiment of the present invention, the step of receiving a definition of a moment comprises receiving an indication that a user wishes to photograph candles being blown out and wherein the target object comprises candle flames.

Further in accordance with a preferred embodiment of the present invention, the target object comprises an active subject.

Still further in accordance with a preferred embodiment of the present invention, the target state comprises a state at which the target object's level of motion is locally maximal.

Further in accordance with a preferred embodiment of the present invention, the target state comprises a state at which the target object's level of motion is locally minimal.

Further in accordance with a preferred embodiment of the present invention, the step of receiving a definition of a moment comprises receiving an indication that a user wishes to photograph candles being blown out and wherein the target object comprises candle flames.

Additionally in accordance with a preferred embodiment of the present invention, the target object comprises a subject with moving limbs.

Further in accordance with a preferred embodiment of the present invention, the target object comprises a face and the target state comprises a facial expression.

Further in accordance with a preferred embodiment of the present invention, the facial expression comprises a non-blinking expression in which the subject is not blinking.

Still further in accordance with a preferred embodiment of the present invention, the step of inspecting comprises anticipating a non-blinking expression and ensuring generation of a non-blinking image by generating the trigger upon detection of a blink so as to generate the non-blinking image before a subsequent blink.

Additionally in accordance with a preferred embodiment of the present invention, the facial expression comprises a smile.

Further in accordance with a preferred embodiment of the present invention, the facial expression comprises a surprised expression.

Still further in accordance with a preferred embodiment of the present invention, the target object comprises a face and the target state comprises a facial expression.

Further in accordance with a preferred embodiment of the present invention, the facial expression comprises a non-blinking expression in which the subject is not blinking.

Still further in accordance with a preferred embodiment of the present invention, the facial expression comprises a smile.

Additionally in accordance with a preferred embodiment of the present invention, the facial expression comprises a surprised expression.

Also provided, in accordance with a preferred embodiment of the present invention, is a digital photography method comprising analyzing a stream of digital images of a scene and generating an output image of the scene by performing a local image processing operation selectively on a portion of an image of the scene, the portion comprising an image of less than the entirety of the scene.

Further in accordance with a preferred embodiment of the present invention, the scene includes moving objects and a background and wherein the local image processing operation comprises an operation of replacing images of moving objects with images of the background the objects are obscuring.

Still further in accordance with a preferred embodiment of the present invention, the generating step comprises inspecting a plurality of candidate images of a portion of the scene and selecting an individual candidate image from among the plurality of candidate images which is likely to represent the background.

Further in accordance with a preferred embodiment of the present invention, the selecting step employs at least one of the following selection criteria: the duration of occurrence of an individual candidate image, and the extent to which the individual candidate image matches adjacent candidate images.

Still further in accordance with a preferred embodiment of the present invention, the local image processing operation comprises a noise reduction operation.

Still further in accordance with a preferred embodiment of the present invention, the noise reduction operation is performed differentially on portions of the image such that the extent of noise reduction is a decreasing function of the level of change within the portions.

Additionally in accordance with a preferred embodiment of the present invention, the noise reduction operation is performed selectively, only on portions of the image in which there is only a minimal level of change.

Also provided, in accordance with a preferred embodiment of the present invention, is digital camera apparatus comprising a digital imaging device operative to generate a plurality of preliminary digital images of a scene defining a plane; a noise reduction processor operative to generate from the plurality of preliminary digital images, an output image of the scene with a reduced amount of noise, the noise reduction processor comprising an image aligner which uses image processing to generate a plurality of aligned digital images from the plurality of preliminary digital images by laterally and rotationally aligning the plurality of preliminary digital images about an axis of rotation disposed perpendicular to the plane of the scene.

Additionally provided, in accordance with a preferred embodiment of the present invention, is self-photography apparatus comprising: a digital imaging device generating a stream of images of a location; and a self-photography analysis and control unit operative to perform image processing on at least a portion of the stream of images of a location in order to identify a moment at which an image of the location will comprise a successful self-photograph of a photographer's self at that location.

Further in accordance with a preferred embodiment of the present invention, the self-photography analysis and control unit is operative initially, to identify a photographer's arrival at the location and subsequently, to identify that the photographer is now motionless at the location.

Further provided, in accordance with a preferred embodiment of the present invention. is a digital photography system comprising: a digital image stream analyzer operative to analyze a stream of digital images of a scene; and a local image processing output image generator operative to generate an output image of the scene by performing a local image processing operation selectively on a portion of an image of the scene, the portion comprising an image of less than the entirety of the scene.

Additionally provided, in accordance with a preferred embodiment of the present invention, is a digital photography method comprising: generating a plurality of preliminary digital images of a scene defining a plane; generating from the plurality of preliminary digital images, an output image of the scene with a reduced amount of noise, including use of image processing to generate a plurality of aligned digital images from the plurality of preliminary digital images by rotationally aligning the plurality of preliminary digital images about an axis of rotation disposed perpendicular to the plane of the scene.

Further provided, in accordance with a preferred embodiment of the present invention, is a method for self photography comprising generating a stream of images of a location; and performing image processing on at least a portion of the stream of images of a location in order to identify a moment at which an image of the location will comprise a successful self-photograph of a photographer's self at that location.

Additionally provided, in accordance with a preferred embodiment of the present invention, is a multi-mode digital camera apparatus comprising digital imaging apparatus operative to generate an output image of a location L at a time t; and a time identifier operative to identify time t as a function of a user-selected photography task.

Further in accordance with a preferred embodiment of the present invention, the time identifier is operative to anticipate time t and to trigger operation of the digital imaging apparatus at time t.

Still further in accordance with a preferred embodiment of the present invention, the time identifier is operative to select, within a stream of digital images generated by the digital imaging apparatus, an image generated at time t.

Further provided, in accordance with a preferred embodiment of the present invention, is a multi-mode digital photography method comprising generating an output image of a location L at a time t, and identifying time t as a function of a user-selected photography task.

Still further in accordance with a preferred embodiment of the present invention, the image processing identifies a moment at which the photographer has completed at least one of the following actions:

a. has reached location L;

b. has become generally motionless; and

c. has smiled.

Additionally in accordance with a preferred embodiment of the present invention, the moment definition input device generates a definition of the moment which comprises a definition of at least one target state of at least one corresponding target object and wherein the moment comprises a moment at which at least one target object is in the at least one target state.

Further in accordance with a preferred embodiment of the present invention, the moment definition input device generates a definition of the moment which comprises a definition of a target state of a target object and wherein the moment comprises a moment at which the target object is in the target state.

Still further in accordance with a preferred embodiment of the present invention, the scene includes moving objects and a background and wherein the local image processing operation comprises an operation of replacing images of moving objects with images of the background the objects are obscuring.

According to a preferred embodiment of the present invention, a photography option is provided in which only the background of a scene appears in a final photography product, without people or vehicles or other moving identities which temporarily obscure portions of the scene.

According to another preferred embodiment of the present invention, a night or low illumination photography option is provided in which noise due to long exposure time, is reduced. This is preferably done by image averaging with factoring out of camera motion and moving objects which occur in the course of the various images which are generated during the long exposure time and combined.

Also provided is image generation apparatus for use in conjunction with a digital imaging device, the apparatus comprising any of the above embodiments, minus the digital imaging device and/or minus functionalities such as memory provided within a conventional digital imaging device. Each of the above embodiments may be coupled to or associated with or used in conjunction with, a conventional digital camera or other digital imaging device.

The term "digital imaging device" or "digital camera" is intended to include any imaging device which generates, inter alia, a digital representation of a scene such as but not limited to a digital camera, a CCD array and associated digitizer, a CMOS detector, and any personal device that includes a digital camera such as a cellular phone or hand-held device which has digital-photographic functionality.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated from the following detailed description, taken in conjunction with the drawings in which:

FIG. **1** is a simplified pictorial illustration of a digital camera system constructed and operative in accordance with a preferred embodiment of the present invention.

FIGS. **2**A-**2**L are simplified pictorial illustrations of the camera system of FIG. **1** after selection of an individual option by the user;

FIG. **3** is a simplified functional block diagram illustration of the digital photography system of FIG. **1**, constructed and operative in accordance with a preferred embodiment of the present invention;

FIG. **4** is a simplified pictorial illustration of a timeline suitable for any of the "catch the moment" applications in which moment anticipation functionality described herein is operational;

FIGS. **5**A and **5**B, taken together, form a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3**;

FIG. **6** is a pictorial and time-line diagram illustrating an example of the operation of the object-at-location analysis and control unit **310** of FIG. **3**, according to a preferred embodiment of the present invention;

FIG. **7** is a simplified functional block diagram illustration of the object-at-location analysis and control unit **310** of FIG. **3**, constructed and operative in accordance with a preferred embodiment of the present invention;

FIGS. **8**A and **8**B, taken together, form a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **7**;

FIGS. **9**A and **9**B, taken together, form a simplified flowchart illustration of a preferred method of operation for the apparatus of the moving object detection **700** of FIG. **7**;

FIG. **10** forms a simplified flowchart illustration of a preferred method of operation for the filtering unit **720** of FIG. **7**, which is operative to filter out all moving objects not of interest;

FIG. **11** forms a simplified flowchart illustration of a preferred method of operation for the apparatus of the time of arrival estimator **730** of FIG. **7**;

FIG. **12** forms a simplified flowchart illustration of a preferred method of operation for the apparatus of the selector **790** of FIG. **7**;

FIG. **13** is a pictorial and time-line diagram illustrating an example of the operation of the high/low motion analysis and control unit **320** of FIG. **3**, according to a preferred embodiment of the present invention;

FIG. **14** is another pictorial and time-line diagram illustrating an example of the operation of the high/low motion analysis and control unit **320** of FIG. **3**, according to a preferred embodiment of the present invention;

FIG. **15** is a simplified functional block diagram illustration of the high/low motion analysis and control un it **320** of FIG. **3**, constructed and operative in accordance with a preferred embodiment of the present invention;

FIGS. **16**A and **16**B, taken together, form a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **15**;

FIG. **17** forms a simplified flowchart illustration of a preferred method of operation for the apparatus of the motion level threshold unit **1530** of FIG. **15**;

FIG. **18** is a graph of motion level vs. time, useful in determining an appropriate time at which to trigger imaging and/or save an image, in low motion detection applications;

FIG. **19** is a pictorial and time-line diagram illustrating an example of the operation of the facial features analysis and control unit **330** of FIG. **3**, according to a preferred embodiment of the present invention;

FIG. **20** is a simplified functional block diagram illustration of the facial features analysis and control unit **330** of FIG. **3**, constructed and operative in accordance with a preferred embodiment of the present invention;

FIG. **21** forms a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **20**;

FIG. **22** is a simplified functional block diagram illustration of the background building analysis and control unit **340** of FIG. **3**, constructed and operative in accordance with a preferred embodiment of the present invention;

FIGS. **23**A and **23**B, taken together, form a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **22**;

FIG. **24** is a pictorial and time-line diagram illustrating an example of the operation of the background building analysis and control unit **340** of FIG. **3**, according to a preferred embodiment of the present invention;

FIG. **25** is a simplified functional block diagram illustration of the sub-image analyzer **2240** of FIG. **22**, constructed and operative in accordance with a preferred embodiment of the present invention;

FIG. **26** forms a simplified flowchart illustration of a preferred method of operation for the apparatus of the sub-image variability test unit **2500** of FIG. **25**;

FIG. **27** is a simplified functional block diagram illustration of the candidate list update unit **2510** of FIG. **25**, constructed and operative in accordance with a preferred embodiment of the present invention;

FIG. **28** forms a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **27**;

FIG. **29** is a simplified functional block diagram illustration of the candidate list selector **2520** of FIG. **25**, constructed and operative in accordance with a preferred embodiment of the present invention;

FIG. **30** forms a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **29**;

FIG. **31** is a simplified flowchart illustration of a preferred method of operation for the apparatus of the background image analyzer **2260** of FIG. **22**;

FIG. **32** is a cartoon illustration of an example of an urban scene in which three persons are strolling by, obstructing the scenic background;

FIG. **33** is a pictorial and time-line diagram illustrating an example of the operation of the noise reduction analysis and control unit **350** of FIG. **3**, according to a preferred embodiment of the present invention;

FIG. **34** is a simplified functional block diagram illustration of the noise reduction analysis and control unit **350** of FIG. **3**, constructed and operative in accordance with a preferred embodiment of the present invention;

FIGS. **35**A and **35**B, taken together, form a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **34**;

FIG. **36** is a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3** when photographing in “active child” mode;

FIG. **37** is a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3** when photographing in “birthday cake” mode;

FIG. **38** is a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3** when photographing in “don’t blink” mode;

FIG. **39** is a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3** when photographing in “dive” mode;

FIG. **40** is a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3** when photographing in “urban” mode;

FIG. **41** is a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3** when photographing in “night” mode;

FIG. **42** is a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3** when photographing in “race” mode;

FIG. **43** is a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3** when photographing in “child/pet running” mode;

FIG. **44** is a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3** when photographing in “smile” mode;

FIG. **45** is a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3** when photographing in “surprise” mode; and

FIGS. **46**A-**46**B, taken together, form a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3** when photographing in “self-photo” mode.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. **1** is a simplified pictorial illustration of a digital camera system constructed and operative in accordance with a preferred embodiment of the present invention including a display of a plurality of photography options **200** which the digital camera system of FIG. **1** provides for a user when s/he presses on menu button **230**. As shown, a manual option is provided which, if selected, enables the user to photograph as is conventional using state of the art digital camera systems. The remainder of the options **200** guide the user in his photography efforts in a plurality of different situations, such as photographing an active child, photographing an individual blowing out candles on a birthday cake, photographing a portrait of a person while s/he is not blinking, photographing a dive e.g. into a body of water, photographing an urban scene including moving people, cars and other objects which are not of interest, photographing a night scene without allowing the low level of illumination to generate a high noise level, photographing the winning moment of a race, photographing a child or pet running up to a given point, photographing a person while s/he is smiling, photographing a person as s/he is surprised, and photographing ones self. It is appreciated that option selection may be effected via any desirable user interface device such as a menu or special button and the display of FIG. **1** is provided merely by way of example.

The system of the present invention is operative generally to provide a plurality of modes within which the imaging device is guided to operate. The modes are operative to automatically shape the imaging process so as to provide the optimal photography product for each situation or option. For example, if the “active child” option is selected, the imaging device is guided to image an active child when his level of activity diminishes to a level low enough to allow an unblurred image. If the "birthday cake" option is selected, the imaging device is guided to image the child at the moment s/he extinguishes the candles e.g. by analyzing previous images to detect flame motion. If the "don't blink" option is selected, the imaging device is guided to image the subject at a moment in which s/he is not blinking e.g. by detecting facial indications that the subject is about to blink and trigger imaging accordingly. If the "dive" option is selected, the imaging device may be guided to image a diver or jumper as s/he hits the water.

If the "urban" option is selected, the imaging device may be guided to image scenery unobscured by moving cars, people or other objects, by digitally "erasing" the cars and/or people and/or objects. If the "night" option is selected, the imaging device is guided to automatically reduce noise resulting from the long exposure time required for night photography. If the "race" option is selected, the imaging device is guided to image at the moment when it is detected, or anticipated, that an object (the winner) is crossing the finish line. If the "child/pet running" option is selected, the imaging device is guided to image at the moment when it is detected, or anticipated, that an object (the child or pet) is arriving at a location at which the user has pointed his or her camera. If the "smile" or "surprise" option is selected, the imaging device is guided to image at the moment when a smile or surprised expression is detected or anticipated to occur. If the "self-photography" option is selected, the imaging device is guided to image only after the self-photographer has reached a target location, has settled herself motionless at that location and, optionally, has smiled.

It is appreciated that the system of the present invention need not provide a separate mode for each option. Instead, it is possible to provide a single mode serving or supporting several options, wherein that mode is parameterized to allow each separate option to be implemented as appropriate.

For example, an "object at location" mode may be provided to operationalize each of the following options: dive, race, child/pet running and self-photo. The "object at location" mode is constructed and operative to image a location when an object arrives thereat. A "high/low motion" mode may be provided to operationalize each of the following options: active child, birthday cake, and self-photo. This mode is constructed and operative to image a subject when the level of motion is appropriate (low or high: low for an active child, to prevent blurring; high for birthday cake candles, to identify the moment at which the candle flames are flickering out, and low for self-photo, to identify the moment at which the self-photographer has settled himself at the photography location). A "facial recognition" mode may be provided to operationalize each of the following options: don't blink, smile, surprise and optionally self-photography. This mode is constructed and operative to image a subject when his facial expression is appropriate for imaging i.e. in the "don't blink", smile and surprise options respectively, when the subject is not blinking, or smiling, or has assumed a surprised expression.

A "noise reduction" mode may be provided to operationalize the night photography option. This mode is constructed and operative, under the "night" option described herein. to combine several images of a poorly illuminated scene, while idenitifying and discarding noise. A "background" mode may be provided to operationalize the urban option. This mode is constructed and operative, under the "urban" option described herein, to combine several images of a scene, characterized in that each portion of the scene is visible in at least one of the images but typically not in all of them.

It is appreciated that more than one mode of operation may be used to operationalize a single option. For example, self-photo tasks may be operationalized by using the system's "object at location" mode to identify that the self-photographer has reached the photography location and by subsequently using the system's "low motion" mode to identify that the self-photographer has arranged himself and is now sitting still. Optionally, the self-photo task may subsequently use the system's "smile" option ("facial recognition" mode) to identify that the self-photographer is smiling.

Preferably, the user is entitled to select or define a logical combination of the options provided by the system of FIG. **1**, for example, the user might define Active Child AND Don't Blink if s/he wishes to photograph an active child while s/he is not blinking. Another example is that the user might define Urban OR Race if s/he wishes, via a single process of definition on his part, to generate two pictures of a race scene including a picture of the winner reaching the finish line and a picture of the backdrop of the race in which the runners and other moving objects have been filtered out. Typically, these logical combinations are implemented, in the system, simply by defining each specific logical combination as a separate option to be supported by the system.

Preferably, the user is entitled to select or define a logical combination of different configurations for a single mode provided by the system of FIG. **1**, for example the user might define to photograph the first object arriving at a location such as a finish line OR the second object arriving at the location OR the third object arriving at the location if s/he wishes to photograph all three medal-winning athletes finishing an official race.

Preferably, the user is able to select some modes with a simple logic relation between them like 'and', 'or' and 'not'. For example, photograph an active child when s/he is not blinking; or generate two images of the same scene: the urban background thereof and an image of a car that crosses a line in the viewed scene.

Different modes of operation need not be constructed and operative independently of one another. Instead, preferably, the system of the present invention includes a "catch the moment" function and a "scene building" function and the modes described above are constructed and operative within one or another of these functions.

The "catch the moment" function is a group of functionalities relevant to applications in which a particular scene is to be imaged at a particular time. The group of functionalities may for example include a moment anticipator functionality, operative to predict the time at which an application-specific change will occur in the scene. This functionality is useful for many applications in which a scene is to be imaged at a particular time. Another functionality useful for many applications in which a scene is to be imaged at a particular time is a moment selection functionality operative to identify an image within an existing stream of images, with predetermined characteristics. Typically, the object at location, high/low motion and facial recognition modes are each constructed and operative within the "catch the moment" function.

The "scene building" function is a group of functionalities relevant to applications in which a particular scene is to be built up from a plurality of images thereof. Typically, the noise reduction and background modes are each constructed and operative within the "scene building" function. The "scene building" group of functionalities may for example include a sub-image separator functionality, a sub-image analyzer functionality, a scene image generator functionality and a scene analyzer functioniality.

It is appreciated that the above photography options are merely exemplary of the essentially limitless number of special photography situations which may be defined and supported by suitable programming which adapts the operation of the camera, automatically, to the particular characteristics of the particular photography situation. Categories of such photography situations may be defined to include a number of photography options which have similar characteristics. For example, a photography system of the present invention may include "catch the moment" photography options, such as but not limited to the active child, birthday cake, blink, dive, race, child/pet running, smile, surprise and self-photo options, in each of which it is desired to photograph a specific moment having known image characteristics which can either be anticipated, in which case the operation of the camera is timed accordingly, or selected, in which case a sequence of images may be discarded, but for a single image selected at the appropriate time.

As another example, a photography system of the present invention may include "scene building" photography options, such as but not limited to the urban and night options, described herein, in each of which it is desired to build an image of a scene using local image processing methods applied to the images arriving from the digital imaging device **10**.

FIG. **2**A-**2**L are simplified pictorial illustrations of the camera system of FIG. **1** after selection of an individual option by the user, at which point the system typically provides the user with instructions as to how to photograph within the selected option. It is appreciated that the particular messages shown and described herein are merely examples. In addition to or instead of the voice, a text message can appear on the screen or any other mode of message presentation may be employed including presentation within a user manual.

If the "manual" option is selected, as shown in FIG. **2**A, there is no message or a minimal message to the user who then proceeds to photograph without intervention or special set-up by the camera system of FIG. **1** other than as is known in the art.

If the "active child" option is selected, as shown in FIG. **2**B, the message to the photographer may be: "Position your child at a desired location, point the camera at the child, press the shutter button and keep the camera still until you hear a beep".

If the "birthday cake" option is selected, as shown in FIG. **2**C, the message may be: "Point the camera at the flames of the candles, press the shutter button and keep the camera still until you hear a beep".

If the "don't blink" option is selected, as shown in FIG. **2**D, the message may be: Point the camera at your subject's face, press the shutter button and keep the camera still until you hear a beep".

If the "dive" option is selected, as shown in FIG. **2**E, the message may be: "Point the camera at the airspace in front of the diving board or at the water beneath the diving board. Press the shutter button and keep the camera still until you hear a beep".

If the "urban" option is selected, as shown in FIG. **2**F, the message may be: "Point the camera at your urban scene. Don't worry about people or cars obstructing the scene. Your camera will erase them for you. Press the shutter button and keep the camera still until you hear a beep. Be patient-this may take a while."

If the "night" option is selected, as shown in FIG. **2**G, the message may be: "Point the camera at your night scene. Press the shutter button and keep the camera still until you hear a beep. Be patient-this may take a while."

If the "race" option is selected, as shown in FIG. **2**H, the message may be: "Point the camera at the finish line. Press the shutter button and keep the camera still until the race is over and you have heard a confirming beep."

If the "child/pet running" option is selected, as shown in FIG. **21**, the message mav be: "Choose a location. The camera will photograph your subject as it runs by this location. Point the camera at this location, Press the shutter button and keep the camera still until you hear a beep".

If the "smile" option is selected, as shown in FIG. **2**J, the message may be: "Point the camera at your subject's face. Press the shutter button and keep the camera still until you hear a beep".

If the "surprise" option is selected, as shown in FIG. **2**K, the message may be: "Point the camera at your subject's face. Press the shutter button and keep the camera still until you hear a beep".

If the "self-photo" option is selected, as shown in FIG. **2**L, the message may be: "Choose a location. Point the camera at your location and press the shutter button. Walk to your location, stand still (optional, and smile) until you hear a beep."

FIG. **3** is a simplified functional block diagram illustration of the digital photography system of FIG. **1**, constructed and operative in accordance with a preferred embodiment of the present invention. The digital imaging device **10** may comprise digital imaging apparatus similar or identical to that provided within any suitable digital camera such as the following state of the art digital camera: SONY DSC-T7, Olympus C-8080 or Canon PowerShot SD500.

As shown, a plurality of imaging analysis and control units **310**, **320**, **330**, **340** and **350** are preferably provided to carry out a corresponding plurality of photography task types differentially, as a function of the known characteristics of each photography task type e.g. each of the example options shown in FIG. **1**. A selector **100** selects one of these as a function of a user selected option, as shown in FIG. **1**, and optionally, other input data as shown. Each option preferably is associated with a configuration stored in configuration database **70**. The configuration determines e.g., definition of camera response time, at unit **50**.

According to a preferred embodiment of the present invention, a scene imaging, analysis, creation and control functionality is provided which is operative to carry out photography tasks in which it is desirable to combine a plurality of images into a single final image e.g. as in night photography and as in urban scene photography in which moving objects obscure various portions of a backdrop in various different scenes. A moment anticipation functionality may be provided to carry out photography tasks in which it is necessary and possible to anticipate a particular moment at which imaging should take place, long enough before that moment to enable activation of the imaging process. e.g. 0.1-5 seconds before the imaging process is to be activated. An example of such a task is photographing the winning moment in a race. A moment selection imaging analysis and control functionality may be provided to carry out photography tasks in which it is desired to select an image from a stream of images, immediately but retroactively. If flash is used, for example, the moment selection functionality is typically not appropriate whereas the moment anticipation functionality is appropriate because it enables the flash to be activated at the exact moment at which imaging is supposed to occur. If a baby randomly waving her arms and legs is imaged, for example, the moment selection functionality may be appropriate because the child's movements are not easily predictable such that the moment anticipation functionality may not be able to operate effectively.

As shown, selector **100** selects the appropriate one of the imaging, analysis and control units depending on the photography task. Typically, digital imaging parameters provided by the digital imaging device **10** parameterize each photography task to allow the selector **100** to perform its selection function appropriately. It is appreciated that the specific imaging analysis and control units shown are merely exemplary of the possible different units which may be provided in any suitable combination.

The live image stream generated by the digital imaging device need not be at conventional video sampling rate and may, for example, be within the range of 2-120 images per second.

If the only imaging analysis and control device provided is based on moment anticipation functionality, a lower resolution stream may be employed such as a stream of hall the requested photo resolution since digital imaging device **10** is the unit which feeds the final image into memory. If moment selection functionality is used, full resolution (as set by the user via digital imaging device **10**) is typically provided since the analysis and control unit feeds the final image into memory **80**.

If the bandwidth from digital imaging device **10** to selector **100** is limited, the resolution may be reduced in anticipation, while increasing the stream rate.

It is appreciated that at least one of the units **30**, **50**, **70**, **80**, **100**, **310**, **320**, **330**, **340** and **350** may reside on an integrated circuit or a chip constructed and operative to reside within digital camera housing. Alternatively, these may be provided within a small external device e.g. card which may be operatively associated with a digital camera. Another alternative is that at least one of the functional units (**30**, **50**, **70**, **80**, **100**, **310**, **320**, **330**, **340** and **350**) may be retrofit onto an existing integrated circuit or chip, such as a programmable CPU, forming part of an existing digital camera system.

According to another preferred embodiment of the present invention, an external device such as a personal computer is provided, that may receive the images and the option type from an input device such as the input device of FIG. **1**. The camera may save only the option type to its memory, and an external device may read the option type along with images arriving from the memory of digital imaging device **10** and may perform the image selection or scene creation functions. The results may be saved in the external computer or in the memory of the digital imaging device **10**, and the images which are not required or were not selected may be, but need not be, erased or allowed to be overridden

The units **310**, **320**, **330**, **340** and **350** can each be a separate integrated circuit or a chip or alternatively, some or all of these may be implemented on one chip or integrated circuit.

If moment selection functionality or scene building functionality are selected and units **310** or **320** or **330** or **340** or **350** operate relatively slowly, e.g. for "heavy" applications, the stream generated by digital imaging device **10** may be a delayed stream. For example, the digital imaging device **10** may save some images and then recall them from memory and transmit them as a stream to the selected unit.

It is appreciated that the final image memory of FIG. **3**, which stores the output photograph, need not be separate from the memory of digital imaging device **10** and instead may be integral therewith. It is appreciated that, when the moment selection functionality of the present invention is employed, memory **80** may save not only a final image but rather substantially all images from the live image stream generated by digital imaging device **10**. A final image may then be selected by means of a keep command issued by a selected one of the analysis and control units. For all images other than the final image, the selected analysis and control unit typically issues an override command rather than a keep command.

The selector **100** simply stores the relevant unit **310**, **320**, **330**, **340** or **350** for each of the options supported e.g. each of the options illustrated in FIG. **1**.

It is appreciated that more than one level of photography situations may be defined by the photography task-specific camera system of the present invention. For example, the display **210** of FIG. **1** may include an "advanced" button **220** which, if selected, opens a menu. e.g. on display **210**, as shown in FIG. **1**. The user may be invited to select one of a plurality of modes such as object at location, high/low motion, facial recognition, noise reduction, and background. The modes may include any or all of the following:

Object at location: Photographing a defined object as it reaches a defined location, or photographing the first or n'th object to reach that location.

High/low motion: Photographing a moving object at a moment of zero or locally minimal motion, or at a moment of locally maximal motion.

Facial recognition: Photographing a subject at a moment at which his facial expression corresponds to a predefined description.

Noise reduction: Reducing noise resulting from long exposure time e.g. for night photography situations, even for photography situations in which substantial camera motion and/or motion of objects within the scene are present.

Background: Photographing a background obscured by moving objects, including filtering the moving objects out of the eventual image.

It is appreciated that the apparatus and methods shown and described herein are useful not only in a conventional digital camera system but also in systems which include a digital photography component such as cellular telephones, personal digital assistants, and other hand-held and personal devices having digital photography capabilities.

A camera response time determination unit **50** is operative to receive information on the operation mode of the digital imaging device **10** from that device. For example, the digital imaging device **10** may provide unit **50** which indications of whether or not its flash is operative, whether or not its red-eye function is operative, and generally information regarding any aspect of the digital imaging device **10**'s operation mode which affects response time ΔT seconds.

Selector **100** receives ΔT from camera response time determination unit **50** and sends it to the selected analysis and control units (**310**, **320**, **330**, **340** or **350**).

Typically, only analysis and control units that may carry out moment anticipation functionality (e.g. units **310**, **320** or **330**) use ΔT. These units, when carrying out moment anticipation functionality, generate a trigger message indicating that the scene should be imaged ΔT seconds from the present time. The trigger message actuates the digital imaging device **10**, at ΔT seconds from when the trigger is sent, e.g. as shown in FIG. **4**.

FIG. **4** is a simplified pictorial illustration of a timeline suitable for any of the "catch the moment" applications which employ moment anticipation functionality described herein. As shown, a selected one of the analysis and control units **310**, **320** or **330** may generate a trigger which activates the imaging device **10** to take picture at a best time e.g. at a moment at which a predetermined amount of time has elapsed from the moment of triggering.

FIGS. **5**A and **5**B, taken together, form a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3**. In step **520**, ΔT typically depends on flash, flash+red eye, and electronic response time. Steps **535-540** in FIGS. **5**A-**5**B form a stream loop which continues, including performance of all relevant computations, until one or more of the following events occur:

Trigger is sent (anticipation).

Final image generation announcement (selection+scene).

User intervention (such as another press on the shutter button).

As optional setup, the system may be operative to continue the computations of moment selection functionality or scene building functionality described in steps **800-820**, **840** and **850** of FIGS. **8**A and **8**B; steps **1600-1625**, **1640** and **1645** of FIGS. **16**A and **16**B; steps **2100**, **2105**, **2115** of FIG. **21**; FIGS. **23**A and **23**B and FIGS. **35**A and **35**B, for as long as the user continues to press on the shutter button even after a final image generation announcement has been made (step **540**).

FIG. **6** is a pictorial and time-line diagram illustrating an example of the operation of the object-at-location analysis and control unit **310** of FIG. **3**, according to a preferred embodiment of the present invention. FIG. **6** compares the operations of the moment anticipation functionality of the present invention, the moment selection functionality of the present invention and conventional photography functionality, all for an "object at location" type application such as a race situation. A time-lined cartoon of the race is shown in row I. Row II shows the number of time units (images) which remain until the subject crosses the finish-line. In the illustrated embodiment, it is assumed that two time units are required to activate the imaging process. The imaging process may be activated either by conventional shutter button pressing or by an internal application specific imaging control message or "trigger" provided by a preferred embodiment of the present invention. As shown, conventional photography (row V) may result in post-facto imaging, after the race has already ended, imaging which uses moment anticipation functionality (row III) results in a single photo being generated at the right moment, and imaging which uses moment selection functionality (row IV) results in saving images **410**, **420** and **430** from among a stream of such images, numbered respectively **400**, **410**, **420**, **430**, **440**, **450**, ... Each latter image may override each former image in memory. A final image generation announcement is sent to digital imaging device **10** re image **430**.

FIG. **7** is a simplified functional block diagram illustration of the object-at-location analysis and control unit **310** of FIG. **3**, constructed and operative in accordance with a preferred embodiment of the present invention. In FIG. **7**, preferably, the user can set a "location mode" defining when an object of interest is to be imaged, as comprising any of the following:

Reaching a specified area.

Crossing a specified line.

Comes closest to a given point.

Strays farthest from a given point.

It is appreciated that a user setting is not limited to the above location modes but can be any other location based functions, e.g. it may be desired to image an object when it strays maximally from a specified line instead of when one of the above criteria occurs. The location mode may also exist in the database **70**.

It is appreciated that detection of an object in a specified location or in compliance with any suitable location criteria such as the above four criteria, need not be based on motion detection algorithm and instead may be based on other suitable methods such as tracking, segmentation or recognition.

It is appreciated that an "object at location unit" need not photograph an image using location data only and instead may be based on any location related object function, including velocity, direction, acceleration, trajectory type and more. Examples: photographing the object at the maximum velocity imaging the object only When it is found to be moving in a specified direction, or photographing the object at its minimal acceleration.

It is appreciated that an "object at location unit" need not photograph based only on location-related functions and alternatively or in addition may be partly or wholly based on any object data function other than location-related characteristics, Such as photographing the object of the maximum viewed size, maximum brightness, or photographing the object whose color is closest to a predefined color such as red.

It is appreciated that an "object at location unit" need not use only a single event for "triggerin" or "selection" but may use a pre-defined set or sequence or logical combination of events, such as arrival at two points in sequential order, or the following sequence of events: moving to the right, arriving at a point and then moving at highest velocity.

FIGS. **8**A and **8**B, taken together, form a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **7**. Regarding unit **840**, it is appreciated that the saving decision need not use time-based criteria and instead may be based on other criteria such as distance to specified location.

FIGS. **9**A and **9**B, taken together, form a simplified flowchart illustration of a preferred method of operation for the apparatus of the moving object detection **700** of FIG. **7**. Alignment may be performed using registration which is based on template matching techniques, where the displacement of each template is determined by normalized correlation, and the alignment is determined by fitting a camera motion model to template results. Alternatively, alignment may be based on the registration methods described in "Image Registration Methods: A Survey", Barbara Zitova, Jan Flusser. Imaging and Vision Computing 21 (2003), pp. 977-1000 and publications referenced therein. All of the above publications are hereby incorporated by reference. The image warping may use nearest neighbor interpolation, bilinear interpolation and other suitable interpolation methods. Regarding step **905**, the alignment in the current embodiment is carried out in displacement (ΔX, ΔY) and in rotation ($\Delta\theta$).

In step **905**, it is appreciated that the alignment need not be based on displacement and rotation, instead it may be based on less, more or other parameters, such as affine alignment.

In step **915**, it is appreciated that the reference image creation need not use a weighted average and instead may be based on any other image operators and measures of central tendency such as a median between images. In step **930**, it is appreciated that the threshold computation need not be based on histogram's standard deviation and instead may be constant, based on any other histogram related function such as local minimum in the histogram, or an image related function. In step **945**, it is appreciated that blob filtering need not filter only small blobs and instead may filter any other non-interesting blobs, such as blobs with non-interesting shape, color or brightness. In step **950**, it is appreciated that the extraction of tracks from blobs need not use distance-based blob matching and instead may be based on other methods.

It is appreciated that motion detection need not use difference based algorithms and instead may be based on other methods such as image flow.

FIG. **10** forms a simplified flowchart illustration of a preferred method of operation for the filtering unit **720** of FIG. **7**, which is operative to filter out all moving objects not of interest.

FIG. **11** forms a simplified flowchart illustration of a preferred method of operation for the apparatus of the time of arrival estimator **730** of FIG. **7**. Regarding step **1100**, it is appreciated that the estimation need not use polynomial or function fit and instead may be based on other methods. Also, the fit need not use least mean square method and instead may be based on other methods, such as minimum of maximal error.

FIG. **12** forms a simplified flowchart illustration of a preferred method of operation for the apparatus of the selector **790** of FIG. **7**. The selector implementation is typically the same for all analysis and control units that have selectors.

FIG. **13** is a pictorial and time-line diagram illustrating an example of the operation of the high/low motion analysis and control unit **320** of FIG. **3**, according to a preferred embodiment of the present invention in which the unit is operating in low motion detection mode. The motion level threshold for anticipation and for selection is shown to be constant, however in fact it may be changed during processing.

FIG. **13** compares the operations of the moment anticipation functionality of the present invention, the moment selection functionality of the present invention and conventional photography functionality, all for "high/low motion" type applications operative to detect low motion specifically, such as in an image of a hand-waving subject. A time-lined cartoon of the scene is shown in Row I. Row II shows the motion level of the image caused mainly by the waving hand, the motion level threshold for anticipation and the motion level threshold for image selection. In the illustrated embodiment, it is assumed that one time unit is required to activate the imaging process. The imaging process may be activated either by conventional shutter button pressing or by an internal application-specific imaging control message or "trigger" provided in accordance with a preferred embodiment of the present invention. As shown, conventional photography (row V) may result in a smeared image caused by the waving (**1310**). In contrast, imaging which uses moment anticipation functionality (row III) results in a single photo being generated at the moment at which the hand wave is temporarily arrested, and imaging which uses moment selection functionality (row IV) results in saving of images **1330** and **1340** from among a stream of such images, numbered respectively **1300**, **1310**, **1320**, **1330**, **1340**, **1350**, . . . , wherein each later image overrides its predecessors. A final image generation announcement is sent to digital imaging device **10** at (for) image **1340**.

FIG. **14** is another pictorial and time-line diagram illustrating an example of the operation of the high/low motion analysis and control unit **320** of FIG. **3**, according to a preferred embodiment of the present invention in which the unit is operating in high motion detection mode. The motion level threshold for anticipation is typically the same as the motion level from selection. The motion level threshold is shown constant however in fact it may be changed during processing.

FIG. **14** compares the operations of the moment anticipation functionality of the present invention, the moment selection functionality of the present invention and conventional photography functionality, all for "high/low motion" type application operative to detect high motion such as blowing out candles in a birthday cake scene. A time-lined cartoon of the scene is shown in row I. Row II shows the motion level of the image caused mainly by the flickering candle flames and the motion level thresholds, combined for anticipation and selection. In the illustrated embodiment, it is assumed that one time unit is required to activate the imaging process. The imaging process may be activated either by conventional shutter button pressing or by an internal application-specific imaging control message or "trigger" provided by a preferred embodiment of the present invention. As shown, conventional photography (row V) may result in post-facto imaging, i.e. an image after the candles have already been extinguished (**1440**). Imaging which uses moment anticipation functionality (row III) results in a single photo being generated at the precise moment at which the candles are blown out, and imaging which uses moment selection functionality (row IV) results in saving of images **1420** and **1430** from among a stream of such images, numbered respectively **1400**, **1410**, **1420**, **1430**, **1440**, **1450**, . . . , wherein each later image overrides its predecessors. A final image generation announcement is sent to digital imaging device **10** at (for) image **1430**.

FIG. **15** is a simplified functional block diagram illustration of the high/low motion analysis and control unit **320** of FIG. **3**, constructed and operative in accordance with a preferred embodiment of the present invention. In unit **1510**, alignment may be based on the registration methods described in "Image Registration Methods: A Survey", Barbara Zitova, Jan Flusser, Imaging and Vision Computing 21 (2003), pp. 977-1000 and publications referenced therein. All of the above publications are hereby incorporated by reference.

FIGS. **16**A and **16**B, taken together, form a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **15**. In the following description, a low motion detection application is assumed. Modification of the methods for high motion detection appears in (parentheses). The aligner **1510**, as described in step **1605** of FIG. **16**A, may be operative in accordance with the principles of operation described above with reference to FIG. **9**. In step **1610**, the coordinates of the processing window may be transformed using the alignment data in order to process the same area even if the camera is not exactly still.

In step **1635**, the test of the local minimum (maximum) is for assuring the photo has the minimal (maximal) motion level. If the minimum (maximum) is at ΔT, which is the start of the extrapolated data, the motion level would be lower (higher) before the actual photo. If the minimum (maximum) is at $\Delta T+\Delta I$, which is the end of the extrapolated data, the motion level would be lower (higher) after the actual photo. In this case the photo is preferably taken of subsequent images.

In step **1645**, If THR_{save}<=THR_{trig} (THR_{save}>=THR_{trig}), this typically means that an image with motion level of THR_{trig} or less (more) was already saved.

In step **1600**, the previous image memory may not store the previous image only but instead may store other previous images or a combined reference image to be used for motion level computation.

In step **1615**, the motion level need not be based on image differencing but instead may be based on other methods, such as image flow, or histogram difference. It is appreciated that the motion level need not be computed from two images but instead may use more images or alternatively only a single image. In the latter case, motion level can be computed from the image smear, which may be computed, for example, by means of local contrast (e.g. measuring the average edge intensity in a computed window).

In step **1630**, the motion level extrapolation need not use second order polynomial fit, but instead may be based on other methods, such as fit to a general function.

It is appreciated that the aligner **1510** may be disabled to compute the combined motion level of the camera and of the object within the entire processing area. In such a case the image is selected or triggered when the combined motion of the camera and the object is relatively low (high). This option is preferably also used to reduce or eliminate image smear caused by the camera motion.

FIG. **17** forms a simplified flowchart illustration of a preferred method of operation for the apparatus of the motion level threshold unit **1530** of FIG. **15**. The first threshold THR_{SAVE} is typically the minimum (maximum) motion level until current time. Image should typically be saved if its motion level is below (above) this value. For triggering and announcement, the method of FIG. **17** may estimate if there is high probability that the current motion level will be minimal (maximal) until maximum processing time. Therefore, it is based on statistics from the previous images.

It is appreciated that the thresholds need not use such statistics, and instead may be constant, or based on other methods such as direct computation of the expected minimum (maximum) motion level until the maximal computation time.

FIG. **18** is a graph of motion level vs. time, useful in determining an appropriate time at which to trigger imaging and/or save an image, in low motion detection applications. The curve represents the motion level as it changes over time. The diagonal patterned line represents the motion level threshold, THR_{TRIG}. It typically has a non-zero value starting from point C, after there are enough frames for a statistic. Tile dotted line represents THR_{SAVE}. In some periods, it is same as the motion level.

At point A, the motion level is the minimum achieved until this point. Therefore, during the saving process an image will be saved in the final image memory **80**. A final image generation announcement will not be sent since it is the motion level is higher than the THR_{TRIG} (which is zero). For the same reason, no trigger will be sent in for the anticipation process. Similarly, for point B, saving is typically carried out but no announcement or trigger is generated. At point C, THR_{TRIG} has a non-zero value. In the saving process, a final image generation announcement is typically sent since the motion level of the saved image is lower than the threshold. In triggering, a trigger is typically not sent, since in the time region ΔT until $\Delta T+\Delta I$ there is no local minima. At point E, the image capture trigger unit typically decides to send application specific control of triggered final image, since there is local minima (F), that is below THR_{TRIG} in the time region ΔT until $\Delta T+\Delta I$. The trigger is typically sent slightly after E, at time $F-\Delta T$. In the saving process, if user keeps clicking on the shutter button, the image is typically saved in the final memory at point F, and final image generation announcement is typically resent. At the triggering process, application specific control of triggered final image is typically not sent since one was sent already. At point G, the same occurs as at point F.

FIG. **19** is a pictorial and time-line diagram illustrating an example of the operation of the facial features analysis and control unit **330** of FIG. **3**, according to a preferred embodiment of the present invention. In this case ΔT is 2 stream-images long. Typically, when a feature extraction functionality, based on conventional image processing and/or facial feature detection methods, first detects a small smile, application specific control of triggered final image is sent.

FIG. **19** compares the operations of the moment anticipation functionality of the present invention, the moment selection functionality of the present invention and conventional photography functionality, all for "facial features" type application, such as a smiling person situation. A time-lined cartoon of the scene is shown in Row I. Row II shows the number of time units (images) which remain until the person smiles. In the illustrated embodiment, it is assumed that two time units are required to activate the imaging process. The imaging process may be activated either by conventional shutter button pressing or by an internal application specific imaging control message or "trigger" provided by a preferred embodiment of the present invention. As shown, conventional photography (row V) may result in post-facto imaging, after the person has stopped smiling (**1950**). Imaging which uses moment anticipation functionality (row III) results in a single photo being generated at the right moment (i.e. during the smile), and imaging which uses moment selection functionality (row IV) results in a single smile-containing photo or image **1930** being saved from among a stream of such images, numbered respectively **1900**, **1910**, **1920**, **1930**, **1940**, **1950**, ...

FIG. **20** is a simplified functional block diagram illustration of the facial features analysis and control unit **330** of FIG. **3**, constructed and operative in accordance with a preferred embodiment of the present invention.

FIG. **21** forms a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **20**.

Detection of facial features at steps **2110** and **2115** may be carried out using state of the art facial feature detection methods such as those described in the following publications, the disclosures of which are hereby incorporated by reference:

"Real-Time Facial Expression Recognition Based on Features' Positions and Dimensions". Hiroshi Sako and Anthony V. W. Smith, Proceedings of the 13th International Conference on Pattern Recognition, 1996, Volume 3, 25-29 Aug. 1996 Page(s):643-648.

"Facial Expression Recognition Combined with Robust Face Detection in A Convolutional Neural Network", Masakazu Matsugu, Katsuhiko Mori, Yusuke Mitari and Yuiji Kaneda. Proceedings of the International Joint Conference on Neural Networks, 2003. Volume 3, 20-24 July 2003 Page(s): 2243-2246

"Facial Expression Recognition Using Constructive Feedforward Neural Networks", L. Ma and K. Khorasami, IEEE Transactions on Systems, Man and Cybernetics Part B. Volume 34. Issue 3, June 2004 Page(s):1588-1595.

Detection of blinking at steps **2110** and **2115** may be performed using state of the art facial feature detection methods such as those described in the above-referenced Sako and Smith publication. In Sako and Smith, the eye is located using detection of eyebrow and pupil. If only the eyebrow is detected the eye is assumed to be blinking. Another method is to check if the color below the eyebrow is same as the skin color, in which case a blink is assumed to be occurring since the eyelid is apparently visible, or different, in which case a blink is assumed not to be occurring since the eye's pupil is apparently visible.

Since blinking is hard to anticipate at step **2110**, especially when ΔT is above ¼ second, a preferred selected moment to trigger the digital imaging device is upon detection of blinking. At this time there is the highest probability that the subject to be photographed will not blink within a time interval of ΔT from the detected blink.

FIG. **22** is a simplified functional block diagram illustration of the background building analysis and control unit **340** of FIG. **3**, constructed and operative in accordance with a preferred embodiment of the present invention. FIGS. **23**A and **23**B, taken together, form a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **22**. The aligner **2220**, as described in step **2305** of FIG. **23**A, may be operative in accordance with the principles of operation described above with reference to FIG. **9**.

Background image creation may be based on the following steps:

a. For each portion of the scene, there is a list of candidates, i.e. sub-images to be considered for use as the background image of this portion. For example, in a scene portion having a lawn in the background and a moving red car in the foreground, candidates may include green sub-images (corresponding to moments in which the red car is not present), red sub-images (corresponding to moments in which the red car is present) and other sub-images containing a mixture of green and red (corresponding to moments in which the red car is either in a state of arrival or in a state of departure). Each candidate comprises a sub-image and related data.

b. The method first fills in the candidate list using the data in the input stream (from digital imaging device **10** of FIG. **3**) and then selects the best candidate for each portion.

c. A candidate contains a sub-image that was extracted from an image in the scene portion.

d. For each candidate, the occurrence is computed, e.g. the number of images containing the sub-image similar to the candidate sub-image is counted. If the candidate has a high occurrence rate, it is more apt to be used in the background image for the corresponding portion.

e. Another test for each candidate is the fit to the surrounding background. If a candidate matches the background (its borders are similar to the tangent pixels in the background image) it is more apt to be used in the background image for the corresponding portion.

Alignment in step **2305** may be based on the methods described above with reference to FIG. **9**. In step **2310**, a sub-image may be a portion of the image, for example 8*8 pixels, the whole image or even only a single pixel. In a preferred embodiment, the sub-images are arranged as a grid. However, alternatively, sub-images may be arranged in any suitable arrangement which may or may not overlap. Regarding step **2310**, according to a preferred embodiment, the sub-images are square. However, alternatively, they may be any shape and may comprise a set of connected or even unconnected pixels.

Regarding step **2300**, the previous image memory need not store the previous image only but instead may store other previous images or a combined reference image to be used for the alignment process.

In step **2320**, the background image generator need not use image placement but instead may be based on other methods, such as image averaging.

FIG. **24** is a pictorial and time-line diagram illustrating an example of the operation of the background building analysis and control unit **340** of FIG. **3**, according to a preferred embodiment of the present invention.

FIG. **24** describes background image building for a scene with a house, a road and a tree, while three moving persons obscure, at various times, various parts of the scene. A time-lined cartoon of the scene is shown in Row I, Row II shows the temporary background image in the background image memory **2270**. As time goes on, the background image contains fewer and fewer moving objects until it eventually contains only the background scene. At image **2440**, background image analyzer **2260** concludes that the background image is adequate and sends it to the final image memory **80** while sending a final image generation announcement to the digital imaging device **10**.

FIG. **25** is a simplified functional block diagram illustration of the sub-image analyzer **2240** of FIG. **22**, constructed and operative in accordance with a preferred embodiment of the present invention. In the current embodiment 3 candidates are assumed, by way of example, for each sub-image. It is appreciated that the number of candidates may be 2 to infinite.

FIG. **26** forms a simplified flowchart illustration of a preferred method of operation for the apparatus of the sub-image variability test unit **2500** of FIG. **25**. Regarding step **2605**, the variability need not use image differencing but instead may be based on other methods such as image flow or histogram difference. Regarding step **2605**, the variability need not use operation on the raw data of the images but instead may apply filters, such as smoothing filter, or transforms, such as Fourier transform, on the images before computing the variability. Regarding step **2610**, the threshold may not be constant but instead may be user configured or adaptive based on image content, such as proportional to the average of the variability difference for all sub-images.

FIG. **27** is a simplified functional block diagram illustration of the candidate list update unit **2510** of FIG. **25**, constructed and operative in accordance with a preferred embodiment of the present invention.

FIG. **28** forms a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **27**. Regarding step **2805**, similarity need not be based on image differencing but instead may be based on other methods such as image flow or histogram difference. Regarding step **2805** similarity need not use an operation on the raw data of the images but instead may apply filters, such as a smoothing filter, or transforms, such as a Fourier transform, on the images before computing the similarity. Regarding step **2815**, the threshold may not be proportional to the average of difference of previously match sub-images, but instead may be based on other parameters, such as the standard deviation of the difference. Also, the threshold may not be based on the difference of previously matched sub-images, but instead may be based on other methods, such as proportionality to the contrast of the sub-image.

FIG. **29** is a simplified functional block diagram illustration of the candidate list selector **2520** of FIG. **25**, constructed and operative in accordance with a preferred embodiment of the present invention.

FIG. **30** forms a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **29**. Regarding step **3000**, the fit need not use difference between tangent pixels, instead it may be based on other methods such as counting number of almost-same pixels between tangent pixels. In addition, a logical operation on the fit for the sub-image sides may be applied, such as computing the fit for each side separately, and taking the median of the fit values. Also, the fit may need not use only tangent pixels, instead it may use wider area, such as 3 pixels wide. Regarding step **3010**, candidate selection may alternatively be based on other methods, such as taking the candidate with the maximal occurrence with a minimal fit, or scoring each candidate using its occurrence and its fit and selecting the candidate with the best score.

FIG. **31** is a simplified flowchart illustration of a preferred method of operation for the apparatus of the background image analyzer **2260** of FIG. **22**. Regarding step **3100**, testing if the image is adequate need not be based on adequacy of all selected candidates. Instead, the criterion for image adequacy may be that a predetermined percentage, e.g. 95%, of its portions are adequate. Regarding step **3100**, testing if the image is adequate need not use occurrence only, instead it may be based on the candidate fit in addition to or instead the occurrence.

FIG. **32** is a cartoon illustration of an example of an urban scene in which three persons are strolling by, obstructing the scenic background. A moving vehicle and a passing flock of birds also obstruct the background. In this cartoon image, an example computation of the extent of occurrence of various portions of the scene is demonstrated. Dotted lines delimit five example portions A, B, C, D and E from among a grid or other plurality of such portions or sub-images, which covers the image.

The column labeled A, in FIG. **32**, depicts a portion of the candidate list associated with sub-image A and comprising candidates occurring within sub-image A. Similarly, the columns labeled B-E depict portions of the candidate list associated with sub-images B-E respectively.

Portions A-E are characterized as follows:

Portion A: In this portion a car enters the scene. The car brakes in image **3240** and then remains stationary.

In the first image, **3210**, the sub-image enters the candidate list, since the candidate list is empty. The occurrence of the candidate is 1, since it appeared only one time (current time).

In the next image, **3220**, the sub-image is different than the candidate (difference is larger than threshold in step **2805**). Therefore, the new candidate is initialized at step **2815**.

The same is carried out for the next image **3230**. Now there are 3 candidates.

At the next image, **3240**, one more candidate needs to be initialized. However, since there are already 3 candidates, one of them is removed to allow the new candidate. Once a sub-image has been placed in the background image it is typically not removed, even if it has the lowest occurrence.

At image **3250**, the sub-image A' of the scene is same as the top candidate. Therefore, the occurrence is incremented by 1.

At image **3260**, the same is carried out as in image **3250**. The occurrence for the top candidate is incremented to 3.

Portion B: In this portion there is a part of a tree, whereas in image **3230**, there is a flock of birds.

Image **3210**: At the first image, **3210**, the sub-image enters the candidate list, since the candidate list is empty. The occurrence of the candidate is 1, since it appeared only one time (current time).

Image **3220**: Occurrence is incremented to 2 since the sub-image is similar to the first candidate.

Image **3230**: Since there is a large variability (step **2610**), the sub-image does not update the candidate list. The occurrence remains 2.

Image **3240**: same as **3230**.

Image **3250** and **3260**. Same as **3220**, the occurrence being incremented to 3 and 4, respectively.

Portion C: In this portion there is always a top-left part of the tree. For all images the occurrence is incremented by 1.

Portion D: In this portion there is part of the house, which people sometimes pass by and obscure.

Image **3210**: At the first image, **3210**, the sub-image enters the candidate list, since the candidate list is empty. The occurrence of the candidate is 1, since it appeared only one time (current time).

At the next image, **3220**, the sub-image is different than the candidate (difference is larger than threshold in step **2805**). Therefore, the new candidate is initialized at step **2815**.

At the next sub-image, **3230**, the sub-image is same as the second candidate, therefore, its occurrence is increased by 1.

At the next image, **3240**, the sub-image is different than all the candidates (difference is larger than threshold in step **2805**). Therefore, the new candidate (third one) is initialized at step **2815**.

At the next sub-image, **3250**, the sub-image is same as the third candidate, therefore, its occurrence is increased by 1. Now there are 2 candidates with 2 occurrences.

At the next image, **3260**, the sub-image is different than all the candidates (difference is larger than threshold in step **2805**). Therefore, the top candidate (with the lowest occurrence) is removed, and new candidate (top) is initialized at step **2815**.

Portion E: In this portion there is another part of the house where one people passed in front of. The occurrence is incremented by 1 each image, except for image **3240**. In this image the sub-image is different than the candidate, and a new candidate is initialized.

FIG. **33** is a pictorial and time-line diagram illustrating an example of the operation of the noise reduction analysis and control unit **350** of FIG. **3**, according to a preferred embodiment of the present invention. In a conventional photography process using a long shutter, the noise is reduced but the image is smeared due to camera motion and subject motion. A preferred embodiment of the present invention resolves this problem.

FIG. **34** is a simplified functional block diagram illustration of the noise reduction analysis and control unit **350** of FIG. **3**, constructed and operative in accordance with a preferred embodiment of the present invention;

Regarding the aligner (unit **3420**), the methods described above with reference to FIG. **9** may be employed.

FIGS. **35**A and **35**B, taken together, form a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **34**.

Regarding step **3505**, this step may perform alignment which may be based on the registration methods described in "Image Registration Methods: A Survey", Barbara Zitova, Jan Flusser, Imaging and Vision Computing 21 (2003), pp. 977-1000 and publications referenced therein. All of the above publications are hereby incorporated by reference.

Regarding separation step **3510**, the methods described above with reference to FIG. **23** are one suitable implementation for this step.

Regarding step **3515**, it is appreciated that the "used" or "disregarded" marks need not be assigned using difference between image and previous image and instead may use other methods such as image flow or histogram difference, "Used" or "disregarded" marks need not be assigned using the raw data of the images but instead may apply filters, such as smoothing filter, or transforms, such as Fourier transform, on the images before comparing. It is appreciated also that the "Used" or "disregarded" marks need not be assigned using the difference image but instead it may use the current night image in the night image memory **3470**.

Regarding step **3515**, the threshold may not be constant but instead may be user configured or adaptive based on image content, such as proportional to the average of the difference for all sub-images. Regarding step **3535**, testing if the scene is adequate need not be as above but instead may be based on any other desired criteria.

FIG. **36** is a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3** when photographing in "active child" mode.

FIG. **37** is a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3** when photographing in "birthday cake" mode.

FIG. **38** is a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3** when photographing in "don't blink" mode.

FIG. **39** is a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3** when photographing in "dive" mode.

FIG. **40** is a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3** when photographing in "urban" mode.

FIG. **41** is a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3** when photographing in "night" mode.

FIG. **42** is a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3** when photographing in "race" mode.

FIG. **43** is a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3** when photographing in "child/pet running" mode.

FIG. **44** is a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3** when photographing in "smile" mode.

FIG. **45** is a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3** when photographing in "surprise" mode.

FIG. **46** is a simplified flowchart illustration of a preferred method of operation for the apparatus of FIG. **3** when photographing in "self-photo" mode.

It is appreciated that the present invention is not limited to the specifics of the methods particularly shown and described hereinabove e.g. in the flowchart illustrations. The present invention relates generally to providing at least one and preferably many functionalities for effecting a corresponding set of one or many selectable photography tasks. It is appreciated that each photography task may be implemented in many ways

It is appreciated that the selectable photography applications provided by a preferred embodiment of the present invention may be either general or specific. An "object at location" application and a "high motion image at rest" application are both examples of relative general application. A "birthday cake" application, a "smile" application and a "self photo" application are examples of more specific applications. It is appreciated that the apparatus shown and described herein may be appropriately modified or expanded in order to obtain apparatus particularly suited to an essentially number and variety of other applications of any level of generality or specificity.

For example, it may be desired to provide a special mode for photographing handshakes, which is triggered upon detection of contact between two moving hands on which the camera is focused, wherein detection and tracking of the hands takes into account known characteristics of hands such as characteristic color or colors, shape, and direction and velocity of motion in the handshake situation. It may be desired to provide a special mode for photographing graduation ceremonies. It may be desired to customize a particular mode for each type of sport. So for example, in the tennis-customized mode, the digital camera system of the present invention might be operative to detect contact between a ball and a racket e.g. by detecting the known shape and size of a tennis ball and then detecting the deformation of the ball object characteristic of its moment of impact with the racket. Imaging would be triggered at that moment of contact. In a pool-jump application, the system of the present invention would preferably take into account the information known in this application, namely that a child of generally known dimensions, shape and color is about to jump, from a generally known direction, into a body of water of generally known location, shape and color.

Similarly, it may be desired to customize a mode operative to recognize a shower or confetti or a display of exploding fireworks or other effects, using known image processing based on known attributes of these effects, and trigger imaging of those effects at the moment of their occurrence. It is appreciated that a sophisticated digital camera system of the type shown and described herein may provide a user with many dozens of photography options, analogous to conventional electric organs and synthesizers which provide amateur and other musicians with a plethora of selectable musical options.

Similarly, it may be desired to customize various modes for recognizing various facial expressions and imaging these at the right time, e.g. as the target facial expression forms or after it has dissipated. U.S. Pat. No. 5,774,591 to Black et al discusses various publications which describe methods for recognizing facial expressions and applications therefor. Many other such methods are known in the field of image processing or can be developed as a direct application of known image processing techniques.

It is appreciated that the methods and apparatus shown and described herein are particularly suited to applications in which a generally stationary scene, other than one major instance of motion, is to be imaged. For example, the scene might be of a race scene including a group of generally stationary spectators and one major instance of motion namely the running motion of a plurality of athletes. It is appreciated that the apparatus shown and described herein may be modified to allow the processors to differentiate the major instance of motion from other artifactual instances of motion e.g. by known characteristics of the moving object of interest such as but not limited to color, shape, direction of motion, size and any combination thereof.

It is appreciated that various system-selected and system-computed parameters or settings described herein may be replaced by a user's selection of the same parameters or settings, typically within the framework of an "advanced user" GUI.

The specific methods and algorithms described herein to implement each of the analysis and control units of FIG. **3** are only examples of how the various selectable photography options shown herein, and other such options, may be implemented. For example, each photography option may be implemented separately rather than having grouped functionalities which pertain to a group of several photography options such as the "object at location", "high/low motion", "facial features", background building" and "noise reduction" functionalities. Alternatively, different functionalities may be identified. Generally, any system which uses image processing coupled with a knowledge base characterizing one or more selectable photography tasks or options, in order to trigger imaging at an appropriate time, as appropriate for the specific photography task and/or in order to perform photography task-specific image processing operations to enhance the final photographic product, falls within the scope of the present invention.

It is appreciated that the software components of the present invention may, if desired, be implemented in ROM (read-only memory) form. The software components may, generally, be implemented in hardware if desired, using conventional techniques.

It is appreciated that various features of the invention which are, for clarity, described in the contexts of separate embodiments may also be provided in combination in a single embodiment. Conversely, various features of the invention which are, for brevity, described in the context of a single embodiment may also be provided separately or in any suitable subcombination.

It will be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown and described hereinabove. Rather the scope of the present invention includes both combinations and subcombinations of the various features described hereinabove as well as variations and modifications which would occur to persons skilled in the art upon reading the specification and which are not in the prior art.

The invention claimed is:

1. A digital photography method comprising:

receiving a definition of a moment at which an anticipated event is to be photographed, said moment comprising a moment at which a moving object arrives at a location;

using a digital imaging device residing in a digital camera to generate a stream of digital images of a location at which said event is anticipated to occur; and

inspecting said stream of digital images, to anticipate said moment in said stream by predicting the time at which an application-specific change will occur in the scene, and to generate a trigger timed and constructed to trigger generation of an additional image of said location at said moment,

said generation of an additional image being effected by an imaging process;

said inspecting comprising inspecting said stream of digital images, to anticipate said moment at which imaging should take place, long enough before said moment at which imaging should take place to enable activation of said imaging process, by estimating said moving object's time of arrival at the location using said moving object's current and previous locations and using standard deviation of a difference image histogram between a reference image in said stream and a current image.

2. A digital photography system operative in conjunction with a digital imaging device, the system comprising:

a moment definition input device defining a moment at which an anticipated event is to be photographed, said moment comprising a moment at which a moving object arrives at a location;

a stream of digital images, generated by the digital imaging device, of a location at which said event is anticipated to occur; and

a moment anticipator operative to inspect said stream of digital images, to anticipate said moment in said stream by predicting the time at which an application-specific change will occur in the scene, and to trigger generation of an additional image of said location at said moment,

said generation of an additional image being effected by an imaging process;

said moment anticipator being operative to anticipate said moment at which imaging should take place, long enough before that moment to enable activation of said imaging process, by estimating said moving object's time of arrival at the location using said moving object's current and previous locations and using standard deviation of a difference image histogram between a reference image in said stream and a current image.

3. A digital photography method comprising:

receiving a definition of a moment at which an anticipated event is to be photographed;

using a digital imaging device residing in a digital camera to generate a stream of digital images of a location at which said event is anticipated to occur; and

inspecting said stream of digital images, to anticipate said moment in said stream by predicting the time at which an application-specific change will occur in the scene, and to generate a trigger timed and constructed to trigger generation of an additional image of said location at said moment,

said predicting the time comprising:

defining a camera response time, said camera response time being a time interval between sending a trigger to the camera to capture an image and an actual image capture by the camera;

calculating data relating to said stream of digital images; and

estimating said time at which an application-specific change will occur in the scene based on said data relating to said stream of digital images; and

said generating a trigger comprising generating a trigger preceding said time at which an application-specific change will occur in the scene by at least said camera response time.

4. A digital photography method according to claim **3** and also comprising defining a time interval between consecutive images in said stream of digital images and wherein said generating a trigger also comprises generating said trigger based on said time interval between consecutive images.

5. A digital photography method according to claim **4** and wherein said generating a trigger also comprises:

receiving an image from said stream of images at an image receipt time;

defining a time period, beginning at said camera response time after said image receipt time and continuing for said time interval between consecutive images;

generating said trigger if said application-specific change occurs in said time period.

6. A digital photography method according to claim **5** and also comprising generating projected data relating to said time period by extrapolating said data relating to said stream of digital images into said time period.

7. A digital photography method according to claim **3** wherein:

said definition of said moment comprises a definition of at least one target state of at least one corresponding target object; and

said moment comprises a moment at which at least one target object is in said at least one target state.

8. A digital photography method according to claim **7** wherein:

said target state comprises a target location; and

said moment comprises a moment at which said target object has reached said target location.

9. A digital photography method according to claim **8** and also comprising:

defining objects of non-interest; and

filtering said objects of non-interest from said stream of digital images.

10. A digital photography method according to claim **8** wherein said target object comprises a target object reaching said target location after a predetermined number of other objects have reached said target location.

11. A digital photography method according to claim **7** and also comprising measuring a velocity of said target object and wherein said target state comprises a moment when said velocity of said target object is at a maximum value.

12. A digital photography method comprising:

receiving a definition of a moment at which an anticipated event is to be photographed;

using a digital imaging device residing in a digital camera to generate a stream of digital images of a location at which said event is anticipated to occur; and

inspecting said stream of digital images by an image processor residing in said digital camera, to detect, in said stream, a digital image which has captured said moment and selectively storing said digital image which has captured said moment,

said selectively storing comprising:

automatically storing a first image from said stream of digital images of said location at which said event is anticipated to occur; and

for each subsequent image in said stream of images:

comparing said subsequent image to at least one previously stored image; and

automatically storing said subsequent image when said subsequent image is a better representation of said anticipated event than said at least one previously stored image and automatically discarding said at least one previously stored image.

13. A digital photography method according to claim **12** wherein said storing said subsequent image comprises overriding a previously stored image.

14. A digital photography method according to claim **12** wherein a user terminates said selectively storing.

15. A digital photography method according to claim **12** wherein:

said moment comprises a moment at which a target object has reached said location;

said comparing comprises comparing a time said target object will take to reach said location in said subsequent image with a time said target object will take to reach said location in said at least one previously stored image; and

said storing said subsequent image comprises storing said subsequent image when said time said target object will take to reach said location in said subsequent image is less than said time said target object will take to reach said location in said at least one previously stored image.

16. A digital photography method according to claim **12** wherein:

said moment comprises a moment at which a target object has reached said location;

said comparing comprises comparing a the distance between said target object and said location in said subsequent image with a distance between said target object and said location in said at least one previously stored image; and

said storing said subsequent image comprises storing said subsequent image when said distance between said target object and said location in said subsequent image is less than said distance between said target object and said location in said at least one previously stored image.

17. A digital photography system operative in conjunction with a digital imaging device, the system comprising:

a moment definition input device defining a moment at which an anticipated event is to be photographed;

a stream of digital images, generated by the digital imaging device, of a location at which said event is anticipated to occur; and

a moment anticipator operative to inspect said stream of digital images, to anticipate said moment in said stream by predicting the time at which an application-specific change will occur in the scene, and to trigger generation of an additional image of said location at said moment,

said predicting the time comprising:

defining a camera response time, said camera response time being a time interval between sending a trigger to the camera to capture an image and an actual image capture by the camera;

calculating data relating to said stream of digital images; and

estimating said time at which an application-specific change will occur in the scene based on said data relating to said stream of digital images; and

said trigger generation preceding said time at which an application-specific change will occur in the scene by at least said camera response time.

18. A digital photography system operative in conjunction with a digital imaging device, the system comprising:

a moment definition input device defining a moment at which an anticipated event is to be photographed;

a stream of digital images, generated by the digital imaging device, of a location at which said event is anticipated to occur; and

an image selector operative to:

automatically store a first image in said stream of digital images of said location at which said event is anticipated to occur; and

for each subsequent image in said stream of images:

compare said subsequent image to at least one previously stored image; and

automatically store said subsequent image when said subsequent image is a better representation of said anticipated event than said at least one previously stored image,

and automatically discard said at least one previously stored image.

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